

FORTRAN Programs to Process Magsat Data for Lithospheric, External Field, and Residual Core Components

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**FORTRAN PROGRAMS TO PROCESS MAGSAT DATA FOR
LITHOSPHERIC, EXTERNAL FIELD, AND RESIDUAL CORE
COMPONENTS**

by

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ABSTRACT

The FORTRAN programs supplied in this document provide a complete processing package for statistically extracting residual core, external field and lithospheric components in Magsat observations. The data reduction method consists of two stages involving pass-to-pass and gridded map comparisons. To process the individual passes: 1) orbits are separated into dawn and dusk local times and by altitude, 2) passes are selected based on the variance of the magnetic field observations after a least-squares fit of the core field is removed from each pass over the study area, and 3) spatially adjacent passes are processed with a Fourier correlation coefficient filter to separate coherent and non-coherent features between neighboring tracks. In the second stage of map processing: 1) data from the passes are normalized to a common altitude and gridded into dawn and dusk maps with least squares collocation, 2) dawn and dusk maps are correlated with a Fourier correlation coefficient filter to separate coherent and non-coherent features; the coherent features are averaged to produce a total field grid, 3) total field grids from all altitudes are continued to a common altitude, correlation filtered for coherent anomaly features, and subsequently averaged to produce the final total field grid for the study region, and 4) the total field map is differentially reduced to the pole. Source code which provides standard statistical information is also supplied to quantify the performance of the data reduction procedures.

CONTENTS

ABSTRACT	ii
I. INTRODUCTION	1
II. PASS PROCESSING	3
III. MAP PROCESSING	9
IV. CONCLUSIONS	15
V. ACKNOWLEDGEMENTS	15
VI. REFERENCES CITED	16
Figure 1: Data Processing Flow Chart	17
Figure 2: Pass-to-Pass Processing Schematic	19
APPENDIX A: DATA EDITING AND COMPUTING REQUIREMENTS	
Computing Environment	A-1
Helpful UNIX Commands	A-2
Suggested Improvements	A-4
APPENDIX B: PROFILE PROCESSING	
subcore.f	B-1
reorder.f	B-17
massage.f	B-33
movetrunc.f	B-48
fourier1d.f	B-59
combine.f	B-75
gsfc1283 coefficients	B-86
APPENDIX C: MAP PROCESSING	
collocation.f	C-1
fourier2d.f	C-10
avgdifres.f	C-39
sqrmmap.f	C-42
inversion.f	C-45
rmagcov	C-67
APPENDIX D: STATISTICS AND DATA CONVERSIONS	
check.f	D-2
statmat.f	D-7
part2.f	D-10

I. INTRODUCTION

The National Aeronautics and Space Administration (NASA) magnetic field satellite (Magsat) has provided a global data set of geomagnetic field observations. Data retrieved from the satellite have been reviewed by NASA and made available for scientific investigations as the Chronicle and Investigator-B data sets (Langel et al., 1981). Both data sets have been used to evaluate magnetospheric effects, to define the core field and to determine magnetic anomalies at satellite altitudes associated with geologic features. The documentation and FORTRAN source code supplied in this technical memorandum describe a step by step method for processing the Investigator-B data set. The processing helps to define the magnetic anomaly field from lithospheric sources, the influence of external fields, and possible residual core field effects which are not included in current models (e.g., Alsdorf 1991).

The FORTRAN source code has been developed for processing the Investigator-B tapes. However, with adaptations the code could also be applied to the Chronicle series tapes or to other geophysical data sets (e.g., the magnetic field information from the POGO satellites). The code was developed in a UNIX-based environment on color graphics workstations such that compiled versions require user input at the terminal. Default values are noted for all user input variables, thereby facilitating the interactive nature of the processing. Graphics programs are not supplied in this document; however, the gridded data produced by the processing is formatted for standard contouring packages.

The data reduction process was broken into several steps so that modifications to the code could be more easily applied. Also, output from each step can be investigated for refinement purposes by changing the values supplied by the user. The flow chart in Figure 1 outlines each step of the data reduction process and should be referred to for the filenames described in this document. The first stage of processing operates on the individual passes while the second stage processes gridded forms of the data. For study areas covering about one fifth of the globe, it takes about two or three hours of operator

time on a RISC-based computer to generate differentially reduced-to-the-pole grids from the orbital data contained on the Investigator-B tapes. Subsequent runs through the data to adjust the variables will take less time because several of the programs need to be run only once for a study area.

A full consideration of the theoretical details of these processing procedures is beyond the scope of this report. These details are found in the references cited in the software and this report. Additional discussions and explanations can be found in Alsdorf et al. (1991; 1992).

There are six programs (Appendix B) used to process the satellite magnetic data from the individual orbits and five programs (Appendix C) that refine the data in grid form. Several auxiliary programs (Appendix D) are also provided to evaluate the output at different steps of the processing. Appendix A outlines the compile- and run-time considerations, disc storage allocation, and notes several improvements that could be made to the various programs. Chapter II describes the processing of the profiles while Chapter III details the processing of the grids.

II. PASS PROCESSING

The programs used in this section include: 1) **subcore**, 2) **reorder**, 3) **massage**, 4) **movetrunc**, 5) **fourier1d** and 6) **combine**. Appendix A should be reviewed for initial set up information before executing these programs. The following programs are presented in the appropriate running order.

II.A SUBCORE

After compiling each program and copying the data from the Investigator-B tapes to disc (Appendix A), the first program to run is **subcore**. This program reads the data in either sequential or direct access and writes to disc in direct access. Refer to the comment statements in the program when changing the code from the sequential access to the direct access driver. Each written record corresponds to an individual observation point as recorded by the satellite. For each record the first two values are integers (fixed point numbers) indicating the pass number and modified Julian day, respectively, and the remaining values are reals (floating point numbers) indicating location coordinates, core field values and vector magnetic field observations. NASA Technical Memorandum 82160 (Langel et al., 1981) should be consulted for a complete description of these variables. The order of the input files from the tape to disc transfer should be in the same time order as recorded by the satellite. This order will maintain the time orientation of the data which is convenient for subsequent processing. However, this rule is not absolutely necessary because program **reorder** can readjust the data to any required time or space orientation, as explained in Section II.B.

A review of the program description and comment statements in the code provides a complete assessment of the adjustments that are made to the data in **subcore**. The major functions of **subcore** are: 1) acquire only the data within user-defined latitude and longitude limits, 2) separate an individual orbit into its dawn and dusk components, and 3) calculate the core field value at each observation point. The spherical harmonic coefficients through degree and order 13 are used to model the core field and are presented in Appendix B.

After the core field value is subtracted from the observed value a series of values is written to disc. Not all of these values are necessary for future processing and some could be removed from the write statements if disc storage is limited. The subtraction of the core field from the magnetic field observations is not a profile-least-squares procedure (Alsdorf, 1991). The least-squares method of subtraction is performed in program **massage** (Section II.C). After **subcore** is complete, the data files from the tape to disc transfer can be removed from disc storage because the processing no longer accesses these files.

Separate files containing dawn passes and dusk passes are written by **subcore** to disc. These files are run separately through the remaining programs that process the profiles (Figure 1).

II.B REORDER

The major function of **reorder** is to rearrange the input file from a time to a spatial orientation. Ordering the passes by location in space is according either to the average longitude of a pass (the usual choice) or by the average elevation. Reordering the passes by time or pass number is also an option, however, it is seldom used. This program reads the direct access output from **subcore** and also writes out direct access files. This program requires twice the disc space as the size of the input file because it is necessary to create a working file which can be deleted after the run is complete. Once **reorder** has been completed, the 2-integer and 27-real output file from **subcore** can be deleted because the file is no longer necessary for processing.

Subcore and **reorder** complete the standard preliminary processing of Magsat data. The output from **reorder** should be saved, even after running further programs, because data parameters may need adjustments when refining the final output. These adjustments often include rerunning the programs described below.

II.C MASSAGE

As originally designed, **massage** developed a combination of local and regional models of the data in an attempt to remove external field effects by Fourier correlation coefficient filtering. This method encompasses the construction of a "guide function" which is an approximate representation of the influence of external fields in an individual

pass. The guide function and the observations are then transformed by the Fourier program (Section II.E) and wavenumber components which correlate within a user defined range of correlation coefficients are cut from the observed data. Those components which correlate represent the effects of unwanted external fields and are therefore cut from the observed spectrum. However, after many investigations it was found that bandpass filtering could provide acceptable results with less computation and disc storage requirements than the guide function method. However, the options to construct the guide function are still included in **massage** for any research that may require a cubic spline fit to the data.

The major functions of **massage** are now usually limited to the following: 1) remove "spikes" from a profile and linearly interpolate all values at latitude intervals of 0.33 degrees, 2) calculate and subtract a least-squares profile fit of the core field values from the observed values, and 3) write out two corresponding files of an individual profile where one file contains the latitude, longitude and radius (e.g., dk.llr in Figure 1) while the other file holds the magnetic field value for each interpolated observation point (e.g., dk.var). Note that output files from **massage** are sequential access and considerably smaller than previous files because each profile is marked by only one header and either three or one variable(s) depending on file type.

II.D MOVETRUNC

This is the step where the dawn and dusk data sets are subdivided further into altitude bands (Alsdorf et al., 1992). The number and distribution of passes for each altitude band must be maintained to ensure a small distance between adjacent passes as compared to the distance to the lithosphere. For example, over the south polar region there are over 2500 dawn and dusk passes available from Magsat. After separation into four distinct altitude bands, there are over 500 passes for each local time at each altitude (Alsdorf et al., 1992), thus maintaining the density of observations for each band. Non-polar regions will have fewer passes because of the orientation of the satellite, therefore, these regions will probably have less than four altitude bands. For the purposes of this

report we will consider only two bands of altitude separation; lower and upper altitude passes. Therefore, after running **movetrunc**, four sets of data will exist including upper and lower altitude dawn data and upper and lower altitude dusk data.

Before **movetrunc** is run, the program **check** as described in Appendix D should be executed to find passes with unacceptably high variances. Also, the output file of "averaged sorted variables" from **reorder** should be copied and edited for profiles that are above or below the median elevation. Appendix A reviews the UNIX commands which can be used to create the files of pass numbers that separate the passes into upper and lower altitude sets.

Movetrunc reads the file of latitudes, longitudes and radii (e.g., *dk.llr*) as well as the corresponding file of magnetic field values (e.g., *dk.var*) produced from running **massage**. After removing unwanted passes, adjacent profiles are truncated to similar lengths according to the latitude value of each observation along a pass. Figure 2 schematically shows how the passes are truncated. Note that pass 6 is duplicated; one version (6w) is truncated to match the length which overlaps with pass 5 and the other version (6e) is truncated so that it has the same overlapping section as pass 7. This duplication and truncation procedure is repeated for every pass. Reviewing Figures 1 and 2, pass 6 is comparable to *dk.llr* and *dk.var*, 6w is similar to *dk.low.llr.y* and *dk.low.y*, and 6e is like *dk.low.llr.x* and *dk.low.x*. Therefore, two sets of files, offset by one pass, are written to disc so that program **fourier1d** (Section II.E) can correlate the immediately adjacent profiles.

II.E FOURIER1D

This program performs the fast Fourier transform (FFT) and inverse FFT as well as bandwidth and/or correlation coefficient filtering. Complex number notation is used to denote the wavenumber components in the memory of the computer. Options are provided for folding out the edges of the data, smoothing the edges to zero to minimize Gibbs energy effects, and centering the data within an array of zeros. Note that the subroutines of this program are one dimensional versions of those used in **fourier2d** (Section III.B)

The following example demonstrates the size of arrays to use, the percent of data to be folded out and the percent of data to be smoothed to zero in any application. First assume that the study area has a latitude range of 40 degrees. This range results in 121 data points:

$$121 \text{ data points} = (40 \text{ degrees}) / (0.33 \text{ degrees per data point}) \quad (1)$$

The size of FFT array to use should then be set to a power of two greater than 121 data points (128 or 256). In this case 128 allows for minimal folding and smoothing, so that better performance is obtained when 256 is used. The percentage of data to be folded out can be then calculated by

$$(2 * 121 * X\%) + 121 < 256 \quad (2)$$

In using equation 2, the X percentage chosen must satisfy the less than sign. If for example we chose 10 percent, then for 121 data points, 12 values at each end of a pass will be folded out and added to the beginning or end of the profile, so that there are 145 data points ($145 = 12 + 121 + 12$). The following sequence illustrates the mirror folding of data points at each end of the profile obtained by **fourier1d**.

12, 11, ... 2, 1, 1, 2, ... 11, 12, 13, ... 109, 110, 111, ... 120, 121, 121, 120, ... 111, 110

folded data ---|----- original data -----|----- folded data

The percent of data to be smoothed to zero must satisfy

$$(145 * Y\%) < 12 \quad (3)$$

where the Y percentage is chosen so that only the data folded out are smoothed and not the actual data. In this case we might chose a Y percent of 8% which smooths 11 values of each edge of 145 data points ($11 = 0.08 * 145$). Finally the program will center the 145 data points within the FFT array by adding 55 zeros to the beginning and 56 zeros to the end of the 145 data points ($55, 56 = \{256 - 145\} * 0.5$). When the final data set is written to file after inverse transforming, only the original 121 data point positions are used.

This is the first application of the **fourier1d** program and the user should consider bandpass and correlation coefficient filtering of the data at this time.

II.F COMBINE

Combine is run twice when processing the data. In this first application of the

program, the two output files of latitudes, longitudes and radii (e.g., `dk.low.llr.x` and `dk.low.llr.y`) from `movetrunc` were identical except for an offset of one pass between the files. After `fourier1d` is applied in II.E, `combine` is used to find the same pass in the two files and truncate both versions of the pass to a similar length. This application of `combine` as illustrated in Figure 2 is analogous to truncating `6w` and `6e` so that both of these versions of pass 6 are of similar overlapping lengths. Therefore, it is important to input the files in the correct order. However, `combine` will check to see that the user has input the files correctly and if not, will stop execution of the program and issue a warning to the screen.

II.G FOURIER1D

This is the second use of `fourier1d` on the profiles. Here, the passes should only be correlation filtered for similar wavelengths. Bandpass filtering is usually not performed.

II.H COMBINE

This is the second use of `combine` on the profiles. The output of `combine` is chosen as one file of latitudes, longitudes, radii and anomaly values (e.g., `dk.low.llra`) which will be input to `collocation` as described in section III.A for gridding. This single output file is written to disc in formatted-ASCII, sequential-access so that the file may be easily transferred from a workstation to a supercomputer.

This concludes the data processing as applied to passes.

III. MAP PROCESSING

Programs applied for map processing include: 1) **collocation**, 2) **fourier2d**, 3) **avgdifres**, 4) **sqrmap** and 5) **inversion**. Before executing these programs, Appendix A should be reviewed for initial set up information.

Before the programs in this chapter are run, the output file of latitudes, longitudes, radii and anomalies from **combine** (Section II.H) should be transferred from the workstation platform to a supercomputer. This transfer is not absolutely necessary, however the computing speed of a supercomputer facilitates faster processing of matrix inversions and large two-dimensional Fourier transforms.

The four sets of profile data (i.e., upper and lower altitude dawn and dusk orbits) were each processed independently as described in Chapter II. When processing the grids in this chapter, the lower altitude dawn and dusk grids are compared and the upper altitude dawn and dusk maps are compared. At the end of the processing, the lower and upper altitude total field maps can be continued to the same elevation and subsequently correlated and averaged (Alsdorf et al., 1992). The following discussion only addresses a single altitude set of dawn and dusk data, although the other altitude data will also be processed in the same manner to test for lithospheric anomaly features sets.

The program **statmat** included in Appendix D can be run using any combination of the following grids as input. **Statmat** determines a variety of standard statistics necessary for interpretation of the magnetic anomalies and the quality of processing.

The following programs are presented in correct running order.

III.A COLLOCATION

Collocation reads the ASCII free format file from **combine** (e.g., dk.low.llra), which includes arbitrarily distributed data points throughout the study region, and calculates node values at regular intervals over a grid at constant altitude (Goyal et al., 1991; Goyal, 1986). The output grid file from **collocation** is formatted ASCII, where the first row of values in the file is along the southern most latitude from west to east. Coordinates for the

first data point in the array are the western most longitude and the southern most latitude. The next data point is just one grid interval to the east of the first data point and along the latitude coordinate. The remaining data points in the row are successively one grid interval east of the preceding point. The next row of values follows the same west to east orientation as the first row, however this row is one grid interval to the north of the first row. The remaining rows then fill the grid successively from south to north and west to east. All programs that work with the grids keep this same orientation.

The user supplied covariance matrix (Appendix C) that is used in **collocation** has been found to produce acceptable magnetic anomalies (Goyal et al., 1991; Goyal, 1986). The covariance matrix provides a function that is used to calculate weights based on distances between grid nodes and observation points.

Both a dawn grid and a dusk grid at the same altitude are produced by separate runs of **collocation**. These grids correspond to the respective sets of passes from the profile processing. The elevation of the grids should be the same and is commonly chosen as the average elevation of all observations in the dawn and dusk data sets. **Collocation** can be used to predict values at grid points which are separated by distances of equal degrees or equal lengths. For example, when working over the polar regions, the FFT algorithms and filtering routines work best with grids of equal areas denoted by the grid coordinates of equal length separations. The program comment statements should be reviewed for appropriate input parameters when choosing between the above grid coordinate options.

III.B FOURIER2D

The forward and inverse FFT subroutines of this program are the two dimensional versions of those in **fourier1d** (Section II.E). **Fourier2d** offers several data processing filters including both the bandpass and correlation coefficient routines. Additional filters are also included which are not typically used in the Magsat data processing; however, these routines are made available for expanded processing efforts. The directional filtering routine fashions a wedge-shaped filter to pass/reject directional trends of data features, whereas the remaining routines perform flat-earth upward and downward continuation, flat-earth reduction of magnetic total field anomalies to the pole, obtain flat-earth anomaly

derivatives, and adjust the phase and amplitude of the individual wavenumber components. For spherical-earth applications, both the continuation and reduction to pole of data is more suited and better constrained by the matrix inversion methods of program **inversion** (Section III.I) and, therefore, Section III.I should be reviewed for these data processing methods.

The main calling routine of **fourier2d** also differs from **fourier1d** in that it does not loop through successive profiles or maps and it allows for multiple calls to the filters in any user-defined order. The comment statements of **fourier2d** should be reviewed for the correct user input values which control the order and number of times a particular filter is called.

The dawn grid is correlated with the dusk grid such that the correlation coefficient cutoffs are set to pass the coherent and consistent anomalies. The size of the FFT array, the percent of data to be folded out and the percent of data to be smoothed are calculated in similar fashion to those of the profiles as described in Section II.E. However, because these values are applied to the columns as well as to the rows of the matrix, the various percentages will be determined by both the number of rows and columns. The input Y% should be chosen so as not to smooth actual values within the array.

This is the first use of **fourier2d** as applied to the grids and the user should only choose to apply the coefficient filter to the two grids. Alsdorf et al. (1992) review appropriate correlation cutoff values for the south polar region where the auroral external field influences are significant; other regions may require different values depending on the effects of external fields in those areas.

III.C AUXILIARY MAP PROCESSING

The grid processing steps of this section are not necessary for standard map reductions; however, these steps are presented for completeness. The processing of this section removes possible external field influences manifested as coherent differences between the correlated dawn and dusk maps. Also, the standard deviations (ie. energy levels) of the correlated dawn and dusk maps are adjusted to nearly the same level.

III.C.1 AVGdifres

This program can be run up to three times during the data processing; once in this auxiliary section and possibly twice in standard processing. In this initial application, **avgdifres** is used to calculate the difference between the correlated dusk and dawn grids (e.g., `low.diff1`).

III.C.2 FOURIER2D

This is the second application of **fourier2d** on the grids. Here, the difference grid from **avgdifres** (e.g., `low.diff1`) is smoothed with a high-cut filter so that a long wavelength model of the possible influence of external fields is produced.

III.C.3 SQRMAP

At this point, both the difference grid and its low-pass filtered version should be visually inspected to determine if the differences can serve as a model of the expected effects of external fields for the study region. If so, then **sqrmap** subtracts the filtered difference matrix from the correlated dusk or dawn grid. Before the subtraction, the difference matrix is least- squares adjusted to more closely match the correlated dusk or dawn grid under consideration.

This concludes the auxiliary processing section.

III.D AVGdifres

This is the second application of **avgdifres** to the grids. As applied here, **avgdifres** finds the average and the difference of the correlated dusk and dawn grids produced from either **fourier2d** in III.B or **sqrmap** in III.C.3.

III.E FOURIER2D

This is the final application of **fourier2d** to the grids. With this application the averaged grid from **avgdifres** (III.D) is high-cut filtered to remove wavelengths shorter than the elevation of the data set. Magnetic anomaly wavelengths smaller than the magnitude of the elevation of the grid are not apparent at satellite altitudes.

The high-cut filtered output map from this execution of **fourier2d** represents the total field magnetic anomaly map at the particular altitude which is being considered.

III.F MODELING OF THE MAGNETIC ANOMALIES

The processing of the previous sections is repeated over each altitude band (e.g. both the lower and upper altitudes) producing a total field grid for each altitude. As discussed in this section, each total field grid is individually continued to a common altitude using the inversion program, then all continued grids are averaged to produce the final total field grid for the study region. This total field grid can then be differentially-reduced-to-the-pole (DRTP) for geologic interpretations and comparisons with gravitational anomalies.

III.F.1 AVGdifres

This is the final application of **avgdifres** to the grids. Here the smoothed grid from **fourier2d** (III.E) is resampled so that the output matrix can be inverted within the interactive memory allocation of a supercomputer. Generally, resampling should occur at a grid interval less than the high-cut wavelength used in **fourier2d**. This step is not necessary if precautions are taken as described below in section III.F.2.

III.F.2 INVERSION

This modeling program finds the effective susceptibilities which correspond to the total field grid supplied by **avgdifres** (III.F.1) or **fourier2d** (III.E) (von Frese et. al., 1981; 1988). These susceptibilities are then subjected to a core field model to produce the total field anomalies at a user defined altitude, or the susceptibilities can be subjected to a radial field of constant intensity to model the DRTP anomalies. These procedures are equivalent to spherical-earth continuation of the Magsat data. To find the susceptibilities, a core field model expanded through degree and order 13 which can be updated to the mission lifetime is necessary (e.g., Appendix B). If the subject area is large and results in more unknowns than the memory allocation of an interactive session on a supercomputer allows, then one of the following can be applied: 1) a boot strap inversion (von Frese et al., 1988), 2) the matrix inversion routines can be modified to write and read from disc rather than memory, or 3) use batch submission so that the code will be executed during a period of reduced user demand (Appendix A). Documentation in **inversion** describes cpu storage and time requirements in terms of the number of unknowns for any inversion.

After all of the total field grids are continued to an average altitude, the continued grids can be correlation filtered using **fourier2d** and subsequently averaged together to produce the final total field grid for the study area. The algorithms of the averaging code are rather straightforward, and we do not present them in this document. However, the code is available via email as outlined in Appendix A. The continued total field grids can be compared to test the self-consistency of anomaly features. Comparisons are facilitated by differencing the grids and statistical analyses.

This concludes the data processing as applied to the grids.

IV. CONCLUSION

The FORTRAN programs supplied in this document provide processing capabilities for investigating lithospheric, external field, and residual core components in the Magsat data. For extracting lithospheric anomalies, the data processing begins with reading the NASA Investigator-B files and finishes with a differentially-reduced-to-the-pole magnetic anomaly map of the study region.

V. ACKNOWLEDGEMENTS

Programming advise as well as several elements of the software were provided by Drs. Dhananjay Ravat, Gary P. Murdock and Daniel R.H. O'Connell. We also thank Dr. Saul A. Teukolsky for permission to use selected FORTRAN routines from Numerical Recipes. Subroutines **spline**, **splint** and **sort** in programs **reorder**, **massage** and **check** are based on routines in Numerical Recipes in Fortran: The Art of Scientific Computing, published by Cambridge University Press and are used by permission. This memorandum originated as Geological Sciences Computing and Graphics Laboratory Report #1 of the Department of Geological Sciences at the Ohio State University. Elements of the software were developed with funding provided by the NASA Center for Mapping (NAGW-973), Amoco, Arco, Exxon, Texaco and Unocal, and the support of the Ohio Supercomputer Center. The memorandum was completed as part of a NASA Summer research fellowship to DEA at the Goddard Space Flight Center with funding from Hughes-STX.

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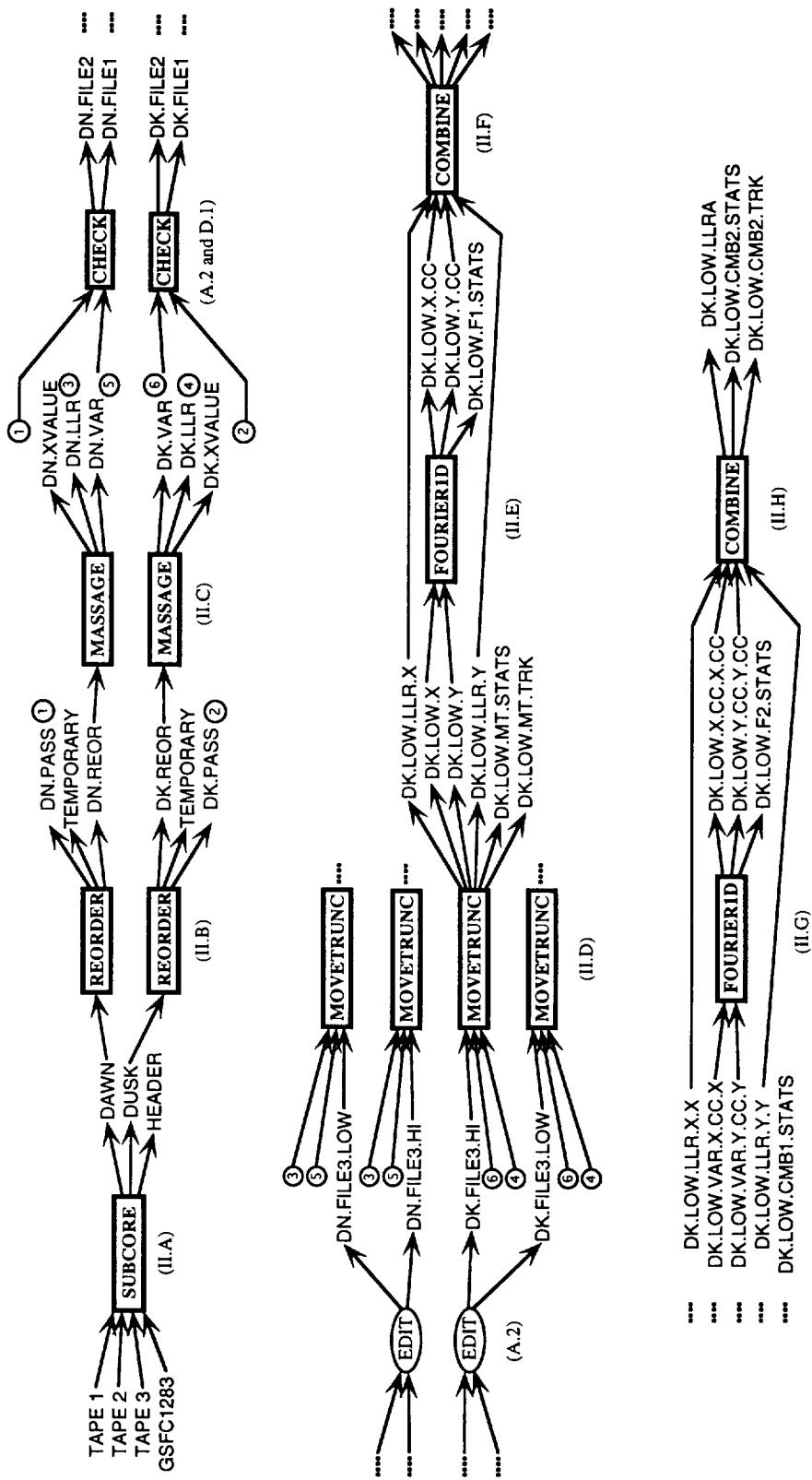


Figure 1: Processing flow chart. Program names are given in boxes and suggested file names follow the arrows. All names are used in the manuscript and values in parentheses are indexed to the appropriate chapter or appendix.

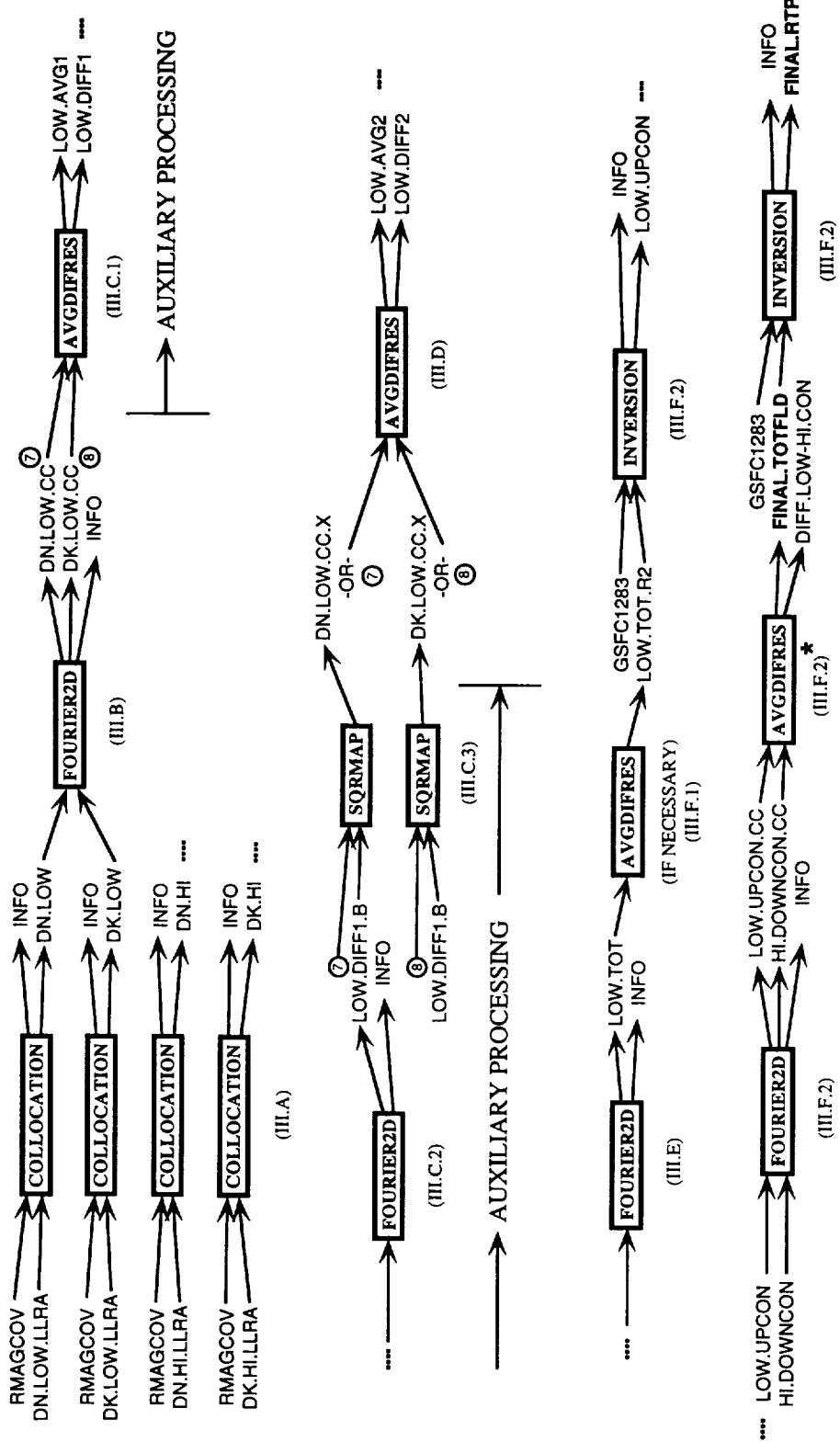


Figure 1 (continued from page 17)

- * If more than two altitude bands are used, then **avgdfrs** can not be used at this point. An auxiliary program to average all correlated continuations is available via email (as described in [Appendix A](#)).

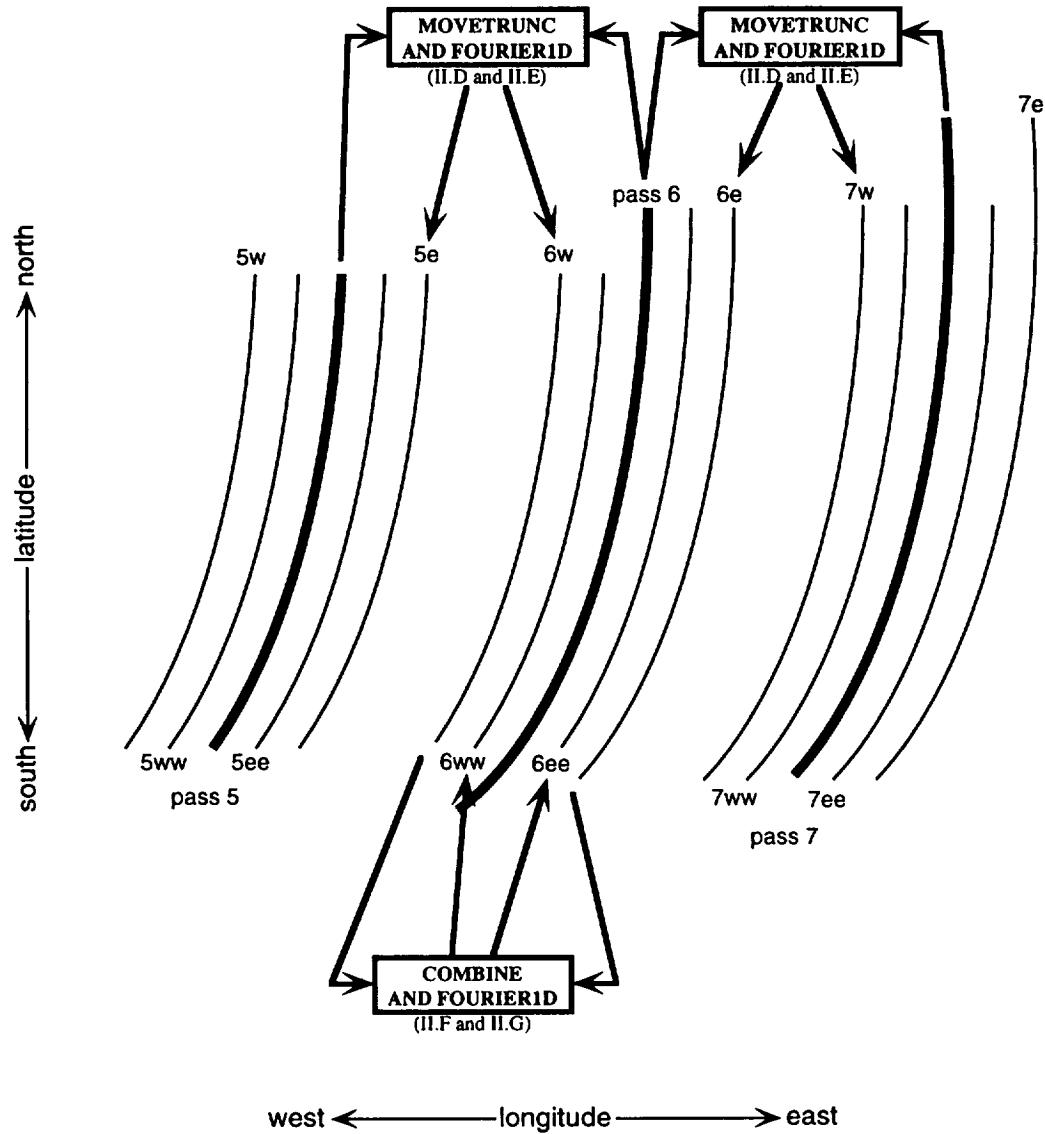


Figure 2 Pass-to-pass processing schematic showing the application of the correlation filter of program **fourier1d** and the truncation of passes by programs **movetrunc** and **combine**. Pass labeling convention follows from the text and program labels are from Figure 1.

APPENDIX A: DATA EDITING AND COMPUTING REQUIREMENTS

This section describes the computing environment necessary to compile and execute the FORTRAN source code as well as disc storage estimates for the files. Additional comments address UNIX commands used to create various input files and possible improvements to the code to increase speed and decrease total file storage requirements.

A.1 COMPUTING ENVIRONMENT

The source code was written, compiled and executed on DEC 3100 color graphics workstations with the Ultrix operating system. Source code in Appendix C was also compiled and executed on the Ohio Supercomputer Center's CRAY Y-MP8 which operates with UNICOS. Other computing systems with FORTRAN 77 compilers should compile, link and execute the code with little or no modifications. Programs **subcore.f**, **reorder.f** and **massage.f** use direct access for file reads and writes and need to be modified for the specific operating system. The comment statements in these programs should be reviewed for additional information. After the code has been transferred to a FORTRAN source code directory, the individual programs should be compiled with the following Ultrix command:

Ultrix prompt: **f77 -static programname.f**

or with the following UNICOS command:

UNICOS prompt: **cf77 -Zp -Wf"-a static" programname.f**

The **-Zp** option allows for optimal autotasking and vectorization and **-static** permits the local variables to be statically allocated. The executable file, **a.out** created by running the FORTRAN compiler command can be moved to the users bin directory and given the same name as the **programname** without the **.f** extension. When executing any of the programs, the user is prompted at the screen (standard input/output device) for filenames and parameters for variables. The variables all have default values listed inside parentheses and the user can type these values as desired. Filenames are suggested in the flow chart of Figure 1.

When running the code on the CRAY, it is convenient to use the batch submission procedures for the inversion code (section III.F.2) because it may require more memory than is allocated under an interactive session. The following is a typical example of the batch submission method:

UNICOS prompt: `qsub -lM 10Mw -lT 3600 shellfile`

The `-lM 10Mw` allocates 10 megawords (80 megabytes) of memory and `-lT 3600` provides 60 minutes of cpu time to run the code in the shell file. Consult the CRAY manual pages for more information.

The total size of the three Investigator-B tapes is around 300 Megabytes (Mb) on a DEC 3100, however other machines may double the size depending on the default number of bytes used to define floating and fixed point numbers. For study areas that constitute about one fifth of the globe, disc storage requirements to run `subcore` range between 45 and 70 Mb depending on global location. To run `reorder`, 90 to 140 Mb are necessary. Between 3 and 6 Mb are needed to run any of the remaining programs in Appendix B. The dawn and dusk grids are generally less than 400 Kilobytes (Kb).

A.2 HELPFUL UNIX COMMANDS

This section describes how to produce files of pass numbers which remove the high variance passes as well as subdivide the passes into altitude sets (e.g. lower and upper altitudes). As defined here, `file1` contains those passes with a variance above a threshold; `file2.low` and `file2.hi` hold pass numbers of either the lower or upper (respectively) altitude pass numbers; and `file3.low` and `file3.hi` include both the large variance pass numbers and the lower or upper altitude pass numbers. The following sequence of commands must be executed once for the dawn data and once again for the dusk data.

As discussed in section II.D, `check` is run immediately before `movetrunc`. Once a maximum variance cutoff has been established, `check` should be run in a UNIX script shell as follows:

```
UNIX prompt> script file1
script prompt> check
script prompt> 1 (type 1 and hit the return)
```

```
script prompt> output file from massage (e.g., dk.var)
script prompt> 1
script prompt> 200.0 200.0 200.0 -200.0 500.0
                           (these are suggested values)
script prompt> yes
script prompt> output file from reorder (e.g., dk.pass)
script prompt> a new file (e.g., file2)
```

Now several hundred pass numbers will be written to the screen and to file1. After the program is finished, exit out of the script shell and use a text editor to access file1.

```
script prompt> exit
UNIX prompt> vi file1 (or use any other editor)
```

Once in the editor, remove every line except those with pass numbers on them so that the final version of file1 resembles the following line.

```
1074 129 75.982 -0.023 -29.244 18.222 1087.460
```

File1 now contains the pass numbers of those passes which have a variance above the user-defined maximum (in this case 500.0 nT²).

Next, make two copies of file2 so that the pass numbers can be separated into low and high altitude sets.

```
UNIX prompt> cp file2 file2.low
UNIX prompt> cp file2 file2.hi
```

Edit file2.low with a text editor, removing all lines where the average elevation is above the median elevation. The median elevation occurs at the mid-line in the file (e.g., if there are 1400 lines in file2, then the median elevation occurs on line number 700). Similarly, edit file2.hi removing all lines where the average elevation is below the median elevation.

Finally, combine the edited file2.low and file2.hi with file1 as follows:

```
UNIX prompt> cat file2.low file1 > file3.low
UNIX prompt> cat file2.hi file1 > file3.hi
```

While processing the lower altitude passes, file3.hi is input to **movetrunc** when the

program asks for "input file of pass numbers not wanted". Conversely, file3.low is input to **movetrunc** when processing the upper altitude passes.

A.3 SUGGESTED IMPROVEMENTS

Several improvements to the code to lower run time and decrease file sizes could be made. The following improvements concentrate on the programs that process the individual profiles as described in Appendix B:

1. **subcore**: Arrays that are in part named "data" could be combined so that the same array is passed to each subroutine.
2. **reorder**: A better method of finding the average longitude of short passes may decrease total run time.
3. **movetrunc and combine**:
 - a) These two programs are very similar and with some modifications the programs could be combined.
 - b) Because the output lat-long-radii files are similar, only one file containing flags indicating the index locations where the passes overlap is necessary for output.

The following improvements concentrate on the programs in Appendix C that process the gridded maps.

1. **collocation**:
 - a) Invert only the symmetric half of the COVM array.
 - b) Use a faster sorting routine for finding the closest points to a grid node location.
2. **inversion**: For arrays larger than the allocated machine memory, an option should be inserted that uses disc space for the matrix inversion.

As a final note, the source code is intended as a framework that allows step-wise processing of the Magsat data. This framework is open for improvements which are heartily encouraged. For copies of the code in this technical memorandum as well as additional auxiliary programs not presented in this document, send an email request to:

alsdorf@geols.mps.ohio-state.edu -or- vonfrese@geols.mps.ohio-state.edu

Comments, criticisms, suggestions for code improvements, as well as requests for code updates should also be directed to the above email addresses.

APPENDIX B: PROFILE PROCESSING

PROGRAMS

subcore.f
reorder.f
massage.f
movetrunc.f
fourier1d.f
combine.f

DATA FILE

gsfc1283


```

program subcore
  real*4 rbuff(3024/4),minlat,maxlat,minlon,maxlon,
  >      seconds(3000),rhead(2228/4)
  integer*4 ibuff(3024/4),flag1,flag2,headcnt,recnum,
  >      outnum,dnum,dknum,
  >      dndkpass,datacnt,stop10,stop11,
  >      head10,data10,head11,data11,head12,data12,totrecord,
  >      dnrec,dkrec,nowant(50),ihead(2228/4)
  character*80 filename
  character*4 cbuff(3024/4),chead(2228/4)
  character*60 aaid
  equivalence (ibuff,rbuff),(cbuff,rbuff),(flag1,ibuff(1)),
  >      (flag2,ibuff(2)),(ihead,rhead),(flag1,ihead(1)),
  >      (flag2,ihead(2)),(chead,rhead)
  common /latlon/ minlat,maxlat,minlon,maxlon
  common /dndkdat/ dndkdata(1500,26),dkdata(1500,26),
  >      idndata(1500,2),idkdata(1500,2)
  common /coeff/ gg(50,50),ggt(50,50),ggtt(50,50),jnum,knum,
  >      tzero,aaid,mmaxn,ttemp
  common /mainfld/ fld(1500,8),dawne,dawni,duske,duski,dndkpass
  common /thatsit/ outdawn(1500,27),outdusk(1500,27)
  COMMON /NASA/ TG(50,50)
  COMMON /FLDCOM/ ST,CT,SPH,CPH,R,NMAX,BT,BP,BR,B
  COMMON /magfld/ THETA(1500),PHI(1500),ELVO(1500),YEAR(1500)
  common data(3000,26),idata(3000,2)

c----- program description
c
c subcore reads the 3 NASA INVESTIGATOR-B tapes from disc and obtains
c the data for the user defined area. the program performs the following
c corrections to the data: 1) reorders the dataset from NASA's column
c arrays to user manageable row arrays 2) removes all values at a
c single sampling point if one of those values is flagged by NASA with
c 9999 3) selects the data for the user defined area 4) separates
c the area into dawn and dusk datasets 5) calculates the core-field
c value for every data point along the dawn or dusk profile and saves
c that value in an array 6) removes the core-field values from the
c data point along a dawn or dusk profile 7) removes NASA's ring-
c current correction and 8) writes several values to the output
c files - these values can be determined by looking at subroutine
c corering.
c     NOTE: output unformatted files are direct access
c           input unformatted files are sequential access
c           output formatted files are sequential access
c     NOTE: use NASA Technical Memorandum No. 82160 for a complete
c           description of each variable
c
c program date: 16 apr 91
c
c updates:
c     4 jun 92, added sequential access driver
c     NOTE: the input files are sequential access in this section
c           to use direct access input files, then swap the
c           driver at the end of the code with the currently used
c           sequential access driver.
c     NOTE: if you are working on an ibm rs6000 then the record
c           length for direct access on files 20 and 21 is:
c               recl=116
c           for input of direct access to files 10,11 and 12 then
c           remove the /4 from 3024/4.
c           if you are working on a dec3100:
c               recl=29
c           and keep 3024/4.
c
c
c     write (*,*) 'INPUT FIRST DATASET FROM TAPE TO DISC TRANSFER'
c     read (*,9990) filename
c 9990  format (a80)
c     open (10, file=filename,status='old',form='unformatted')
c     write (*,*) 'INPUT SECOND DATASET FROM TAPE TO DISC TRANSFER'
c     read (*,9990) filename
c     open (11, file=filename,status='old',form='unformatted')
c     write (*,*) 'INPUT THIRD DATASET FROM TAPE TO DISC TRANSFER'
c     read (*,9990) filename
c     open (12, file=filename,status='old',form='unformatted')
c     write (*,*) 'INPUT FIELD MODEL SPHERICAL HARMONIC'
c     write (*,*) 'COEFFICIENTS (GSFC1283)'
c     read (*,9990) filename
c     open (13, file=filename,status='old',form='formatted')
c----- use the following if you want to input your own nowant
c           file
c     write (*,*) '1 to remove certain pass numbers'
c     write (*,*) '0 do no remove any pass numbers'
c     read (*,*) nocnt
c     if (nocnt .ne. 0) then
c       write (*,*) 'input file of pass numbers not wanted'
c       read (*,9990) filename
c       open (14, file=filename,status='old',form='formatted')
c       do i=1,5000
c         read (14,*,end=10) nowant(i)
c       enddo

```

```

c 10      nocnt=i-1
c      endif
c----- the following lines automatically place the nowant
c      pass numbers in the nowant array. these passes are
c      messed up for one reason or another. i'm sure they
c      could be salvaged, but i'm lazy.
nowant(1)=909
nowant(2)=1079
nowant(3)=1206
nowant(4)=2602
nowant(5)=2728
nowant(6)=2744
nowant(7)=2791
nowant(8)=2854
nowant(9)=3059
nocnt=9
write (*,*) 'OUTPUT DAWN DATA FILE OF 2-INTEGERS AND 27-REALS'
read (*,9990) filename
open (20, file=filename,form='unformatted',access='DIRECT',
>      recl=116)
write (*,*) 'OUTPUT DUSK DATA FILE OF 2-I AND 27-R'
read (*,9990) filename
open (21, file=filename,form='unformatted',access='DIRECT',
>      recl=116)
write (*,*) 'OUTPUT HEADERS FILE'
read (*,9990) filename
open (22, file=filename,form='formatted')
c
write (*,*) '0 FOR NO ADDITIONAL INFORMATION'
write (*,*) '1 FOR ONLY Dst INDEXES'
write (*,*) '2 FOR COMPLETE INFORMATION... this is a big file'
read (*,*) info
if (info.gt.0) then
  write (*,*) 'OUTPUT ADDITIONAL INFORMATION ORBIT FILE'
  read (*,9990) filename
  open (23, file=filename,form='formatted')
endif
c
write (*,*) 'MINIMUM AND MAXIMUM LATITUDE OF STUDY AREA'
write (*,*) 'INPUT RANGE IS FROM -90.0 TO 90.0'
read (*,*) minlat,maxlat
write (*,*) 'MINIMUM AND MAXIMUM LONGITUDE OF STUDY AREA'
write (*,*) 'INPUT RANGE IS FROM -180.0 TO 180.0'
read (*,*) minlon,maxlon
c
c----- the following arrays store the spherical
c      harmonic coefficients that describe the
c      core field
READ (13,9926) Jnum,Knum,TtZERO, AaID
9926 FORMAT (2I1,1X,F6.1,A60)
MmAXN=0
TtEMP=0.
50  READ (13,9928) N,M,GNM,HNM,GTNM,HTNM,GTTNM,HTTNM
9928 FORMAT (2I3,6F11.4)
IF (N.LE.0) GO TO 80
MmAXN=(MAX0(N,MmAXN))
Gg(N,M)=GNM
GgT(N,M)=GTNM
GgTT(N,M)=GTTNM
TtEMP=AMAX1(TtEMP,ABS(GTNM))
IF (M.EQ.1) GO TO 50
Gg(M-1,N)=HNM
GgT(M-1,N)=HTNM
GgTT(M-1,N)=HTTNM
GO TO 50
80  CONTINUE
c
dnrec=0
dkrec=0
totrecord=0
datacnt=0
headcnt=0
stop10=0
stop11=0
c
head10=0
data10=0
recnum=1
100 num=1
read (10,end=120) rhead
head10=head10+1
go to 220
c
120 stop10=1
close (10)
write (*,*) 'done with file one'
write (*,*) 'total headers on file one -',head10
write (*,*) 'total data sets on file one -',data10
head11=0
data11=0

```

```

totrecord=totrecord+recnum
recnum=1
c----- use the go to 999 statement if you only
c want to input one file at a time
125  go to 999
      num=1
      read (11,end=150) rhead
      head11=head11+1
      go to 220
c
150  stop11=1
      close (11)
      write (*,*) 'done with file two'
      write (*,*) 'total headers on file two -',head11
      write (*,*) 'total data sets on file two -',data11
      head12=0
      data12=0
      totrecord=totrecord+recnum
      recnum=1
155  num=1
      read (12,end=999) rhead
      head12=head12+1
c
220  continue
c----- if flag1=1 then this is header file
      if (flag1 .eq. 1) then
          if (info .eq. 1) then
              write (23,*) ihead(4),(rhead(i),i=23,34)
          elseif (info .eq. 2) then
              write (23,*) (ihead(i),i=1,4),(rhead(i),i=5,8),
              >           (ihead(i),i=9,10),(rhead(i),i=11,14),
              >           (ihead(i),i=15,16),(rhead(i),i=17,34),
              >           (chead(i),i=35,64),(ihead(i),i=65,67),
              >           (rhead(i),i=68,557)
          endif
          write (22,8880) ihead(4),(rhead(i),i=5,8),(ihead(i),i=15,16)
8880  format (1x,15,4e15.7,216)
      dndkpass=ihead(4)
      duske=rhead(5)
      duski=rhead(6)
      dawne=rhead(7)
      dawni=rhead(8)
      headcnt=headcnt+1
      recnum=recnum+1
c
      if (flag2 .eq. 2) then
c
230  continue
c
      if (stop10.eq.0 .and. stop11.eq.0) then
          data10=data10+1
          read (10, end=120) rbuff
      elseif (stop10.eq.1 .and. stop11.eq.0) then
          data11=data11+1
          read (11, end=150) rbuff
      elseif (stop10.eq.1 .and. stop11.eq.1) then
          data12=data12+1
          read (12, end=999) rbuff
      endif
      recnum=recnum+1
      datacnt=datacnt+1
c----- if flag1=2 then this is a data file
c
      if (flag1 .eq. 1) then
          write (*,*) 'problem with flag1 -',flag1,
          >           'in a data record'
          stop
      endif
      do i=num,num+29
          idata(1,1)=ibuff(5)
          idata(1,2)=ibuff(3)
          xnum=real(i-num)
          seconds(i)=(real(ibuff(4)) + (rbuff(6)*xnum))
      enddo
c----- these do 250 loops reorder the data
c----- from column to row oriented data
      jj=7
      do 250 j=1,25
          do 250 i=num,num+29
              data(i,j)=rbuff(jj)
              jj=jj+1
250  continue
c
      num=num+30
c
c----- if flag2=1 then the next record is
c----- a header and the data information is
c----- complete for this orbit
      if (flag2 .eq. 1) then
          innum=num-1

```

```

c----- search the nowant array for passes
c----- that just didn't happen. the
c----- following passes are doubled and
c----- are considered not wanted:
c----- 909,1079,1206,2602,2728,2744,2791,
c----- 2854,3059
c
c      do i=1,nocnt
c          if (nowant(i) .eq. idata(1,1)) then
c              write (*,*) 'removed pass number ',
c              nowant(i),idata(1,1)
c              if (stop10.eq.0 .and. stop11.eq.0) go to 100
c              if (stop10.eq.1 .and. stop11.eq.0) go to 125
c              if (stop10.eq.1 .and. stop11.eq.1) go to 155
c          endif
c      enddo
c
c      do 270 i=1,innum
c          data(i,26)=seconds(i)
c      continue
c
c          call nine (innum,outnum)
c          innum=outnum
c          call area (innum,outnum)
c          innum=outnum
c          call dawndusk (innum,dnnum,dknum)
c
c          if (dnnum .le. 0) go to 310
c          call pfligrf (dnnum,1)
c          call corering (dnnum,1)
c          do 300 i=1,dnnum
c              dnrec=dnrec+1
c              write (20,rec=dnrec) (idndata(i,j),j=1,2),
c              (outdawn(i,j),j=1,27)
c          continue
c          310
c          continue
c
c          if (dknum .le. 0) go to 360
c          call pfligrf (dknum,2)
c          call corering (dknum,2)
c          do 350 i=1,dknum
c              dkrec=dkrec+1
c              write (21,rec=dkrec) (idkdata(i,j),j=1,2),
c              (outdusk(i,j),j=1,27)
c          continue
c          360
c          continue
c
c----- these ugly little go to's get back to a
c----- header record
c          if (stop10.eq.0 .and. stop11.eq.0) go to 100
c          if (stop10.eq.1 .and. stop11.eq.0) go to 125
c          if (stop10.eq.1 .and. stop11.eq.1) go to 155
c
c      endif
c----- go back and get another data record
c      go to 230
c
c      endif
c
c      elseif (flag2 .eq. 1) then
c          write (*,*) 'a header file had no associated data record'
c          write (*,*) 'this header file has pass number ',ihead(4)
c      endif
c
c      if (stop10.eq.0 .and. stop11.eq.0) go to 100
c      if (stop10.eq.1 .and. stop11.eq.0) go to 125
c      if (stop10.eq.1 .and. stop11.eq.1) go to 155
c
c 999  continue
c          write (*,*) 'total headers on file three -',head12
c          write (*,*) 'total data sets on file three -',data12
c          write (*,*) 'total headers on tapes -',headcnt
c          write (*,*) 'total data sets on tapes -',datacnt
c          totrecord=totrecord+recnum
c          write (*,*) 'total records read -',totrecord
c          write (*,*) 'total records written to dawn file -',dnrec
c          write (*,*) 'total records written to dusk file -',dkrec
c          close (12)
c          close (13)
c          close (14)
c          close (20)
c          close (21)
c          close (22)
c          close (23)
c          stop
c      end
c
c

```

```

subroutine nine (innum,nincnt)
common data(3000,26),idata(3000,2)
c
c----- subroutine description
c      this subroutine removes from the data array all variables
c      associated with a single sampling point if selected variables at
c      that sampling point are greater than 99999.0
c
c      nincnt=0
c
c      do 100 i=1,innum
c          do j=1,3
c              if (data(i,j) .ge. 99999.0) go to 200
c          enddo
c          do j=5,6
c              if (data(i,j) .ge. 99999.0) go to 200
c          enddo
c          do j=8,23
c              if (data(i,j) .ge. 99999.0) go to 200
c          enddo
c          if (idata(i,1) .ge. 9999) go to 200
c          if (idata(i,1).eq.99999.0 .or. data(i,2).eq.99999.0 .or.
c      >      data(i,3).eq.99999.0 .or. data(i,8).eq.99999.0 .or.
c      >      data(i,12).eq.99999.0) go to 200
c          nincnt=nincnt+1
c          do 140 j=1,2
c              idata(nincnt,j)=idata(i,j)
c          continue
c          do 150 j=1,26
c              data(nincnt,j)=data(i,j)
c          continue
c          200 continue
c          100 continue
c
c      return
c      end
c
c
c      subroutine area(innum,outnum)
integer*4 innum,outnum
real*4 minlat,maxlat,minlon,maxlon
common /latlon/ minlat,maxlat,minlon,maxlon
common data(3000,26),idata(3000,2)
c
c----- subroutine description
c      this subroutine removes all data outside of the user defined
c      area.
c
c      outnum=0
c      do 200 i=1,innum
c          if (data(i,1).gt.maxlat .or. data(i,1).lt.minlat .or.
c      >      data(i,2).gt.maxlon .or. data(i,2).lt.minlon) go to 100
c          outnum=outnum+1
c          do 140 j=1,2
c              idata(outnum,j)=idata(i,j)
c          continue
c          do 150 j=1,26
c              data(outnum,j)=data(i,j)
c          continue
c          100 continue
c          200 continue
c
c      return
c      end
c
c
c      subroutine dawndusk (innum,dncnt,dkcnt)
integer*4 innum,dncnt,dkcnt,totcnt
common /dndkdat/ dnddata(1500,26),dkdata(1500,26),
      >      idndata(1500,2),idkdata(1500,2)
common data(3000,26),idata(3000,2)
c
c----- subroutine description
c      this subroutine separates the data array into dawn and dusk data
c      sets.
c
c      data(innum+1,1) = -90.0
c      dkcnt=0
c      dncnt=0
c
c      do 200 i=1,innum
c          if (data(i,1) .lt. data(i+1,1)) then
c              dkcnt=dkcnt+1
c              do 90 j=1,2
c                  idkdata(dkcnt,j)=idata(i,j)
c              continue
c              do 100 j=1,26
c                  dkdata(dkcnt,j)=data(i,j)
c              continue
c          90 continue
c          100 continue
c      200 continue

```

```

100      continue
      elseif (data(i,1) .gt. data(i+1,1)) then
      dncnt=dncnt+1
c----- remove the first "dawn" data point because
c           in reality this point could actually belong
c           to a dusk profile. a look at the longitudes
c           will prove this point. of course with some
c           extra code this point could be saved -- but
c           hey its only one in a thousand!!
c
      if (dncnt .eq. 1) go to 160
      do 140 j=1,2
         idndata(dncnt-1,j)=idata(i,j)
      continue
      do 150 j=1,26
         idndata(dncnt-1,j)=data(i,j)
      continue
      continue
      elseif (data(i,1) .eq. data(i+1,1)) then
         write (*,8880) data(i,1),data(i+1,1),idata(i,1)
8880      format ('two latitudes are equal therefore program skips',
     >           ', the first latitude ',f9.4,' and reviews the',
     >           'second latitude ',f9.4,' for pass number',16)
      endif
200  continue
c
      totcnt = dkcnt + dncnt
      if (totcnt .ne. innum) write (*,8881) dkcnt,dncnt,totcnt,innum
8881 format ('total dusk observations =',i4,' total dawn obs. =',i4,
     >           ', totals added =',i5,' which differs from the input',
     >           ', of the area selected =',i5)
c
      dncnt=dncnt-1
      return
      end
c
c
c subroutine pfligrf (innum,idndk)
c common /dndkdat/ dnddata(1500,26),dkdata(1500,26),
c                   idndata(1500,2),idkdata(1500,2)
c COMMON /magfld/ THETA(1500),PHI(1500),ELVO(1500),YEAR(1500)
c
c*****PROGRAM P F L I G R F
c
c THIS PROGRAM CALCULATES VALUES OF ALL OF THE FOLLOWING ALONG
c MAGSAT PROFILES CREATED BY STEP1P4 FORTRAN AT PURDUE.
c
c      INDEX      VALUE
c      1 - pass number
c      2 - TOTAL FIELD
c      3 - X COMPONENT
c      4 - Y COMPONENT
c      5 - Z COMPONENT
c      6 - INCLINATION
c      7 - DECLINATION
c      8 - latitude point to assure correct points are
c          compared
c
c      YEAR(1)-EPOCH IN YEARS AND DECIMAL FRACTION YEARS (E.G., 1965.75-
c          1 OCT. 65) FOR WHICH THE GEOMAGNETIC REFERENCE FIELD IS TO
c          BE COMPUTED AT OBSERVATION POINTS.
c          THEN THE GEOMAGNETIC FIELD OVER THE OBSER-
c          VATION POINT IS COMPUTED BY SUBROUTINE FIELDG FOR THE EPOCH
c          SPECIFIED BY THE YEAR-INPUT VARIABLE
c
c      TAPE UNITS:
c          4. (U/I).....DATA FILES CREATED BY STEP1P4
c
c          7. (U/O).....OUTPUT...WATCH THE ORDER OF VARIABLES
c
c      revised 25 AUG 90
c
c      this subroutine was modified to read the spherical harmonic
c      coefficients in the main program and transfer those coefficients
c      by a common block. with these modifications, the file holding the
c      coefficients is only read once and not a thousand billion times
c      which decreases total run time on the program. (ok ok, so maybe
c      not a thousand billion times, but only the number of dawn and
c      dusk profiles given to the subroutine.)
c
c      along the way i've removed some useless code that would write
c      items to file 6 or any of a number of additional places
c      depending on which format the user supplied. so if the original
c      is desired, it can be found in programs named the same as
c      the subroutines in this program.
c

```

```

C*****
C
C      if (idndk .eq. 1) then
C          do 50 i=1,innum
C              ipass1=idndata(i,1)
C              mjd=idndata(i,2)
C              secx=dndata(i,26)
C              theta(i)=dndata(i,1)
C              phi(i)=dndata(i,2)
C              elvo(i)=dndata(i,3)
C              ELVO(I) = ELVO(I) - 6371.2
C              IDAYS = 44239 - MJD
C              IF (IDAYS .GT. 0) THEN
C                  FRACY = FLOAT(365-(IDAYS)) / FLOAT(365)
C                  FRACYA = SECX / (3600000.*24.*365.)
C                  YEAR(I) = 1979.0 + FRACY + FRACYA
C              ELSE
C                  FRACY = FLOAT(-IDAYS) / FLOAT(366)
C                  FRACYA = SECX / (3600000.*24.*366.)
C                  YEAR(I) = 1980.0 + FRACY + FRACYA
C              ENDIF
C          continue
C      elseif (idndk .eq. 2) then
C          do 70 i=1,innum
C              ipass1=idkdata(i,1)
C              mjd=idkdata(i,2)
C              secx=dkdata(i,26)
C              theta(i)=dkdata(i,1)
C              phi(i)=dkdata(i,2)
C              elvo(i)=dkdata(i,3)
C              ELVO(I) = ELVO(I) - 6371.2
C              IDAYS = 44239 - MJD
C              IF (IDAYS .GT. 0) THEN
C                  FRACY = FLOAT(365-(IDAYS)) / FLOAT(365)
C                  FRACYA = SECX / (3600000.*24.*365.)
C                  YEAR(I) = 1979.0 + FRACY + FRACYA
C              ELSE
C                  FRACY = FLOAT(-IDAYS) / FLOAT(366)
C                  FRACYA = SECX / (3600000.*24.*366.)
C                  YEAR(I) = 1980.0 + FRACY + FRACYA
C              ENDIF
C          continue
C      endif
C
C      np=innum
C      LQ=1
C      CALL FIELDG (0.,0.,0.,0.,50,LQ,Q1,Q2,Q3,Q4)
C      CALL GEOMAG (NP,IPASS1)
C
C      return
C
C
C      SUBROUTINE GEOMAG (NPTS,IPASS1)
C      COMMON /magfld/ THETA(1500),PHI(1500),ELVO(1500),YEAR(1500)
C      common /mainfld/ fld(1500,8),dawne,dawni,duske,duski,dndkpass
C      INTEGER*4 IPASS1,dndkpass
C
C
C      ****
C      **** THIS SUBROUTINE CALCULATES THE MAGNITUDE, INCLINATION, AND
C      **** DECLINATION OF THE GEOMAGNETIC FIELD ON A GRID NTHETA BY
C      **** NPHI
C      ****
C      THETA,PHI    ** ORIGIN OF THE GRID (DEG.)
C      ELV    ** ELEVATION OF GRID (KILO. ABOVE SEA LEVEL)
C      HTHETA,HPHI  ** GRID SPACING (DEG.)
C      NTHETA,NPHI  ** DIMENSIONS OF THE GRID
C      NF    ** UNIT FILE WHICH WILL STORE THE FIELD
C
C      ****
C      **** SUBROUTINES USED
C      ** FIELDG ** (NASA)
C      ** FIELD ** (NASA)
C      ****
C
C      LL=0
C      RD=180./3.14159265
C
C      DO 100 I=1,NPTS
C          ATHETA = THETA(I)
C          APHI = PHI(I)
C          ELV = ELVO(I)
C          YR = YEAR(I)
C
C          CALL FIELDG (ATHETA,APHI,ELV,YR,50,LL,X,Y,Z,FF)
C
C          H=SQRT(X*X+Y*Y)
C          T=SQRT(H*H+Z*Z)

```

```

finc=RD*ATAN2 (Z,H)
fdec=RD*ATAN2 (Y,X)
fld(i,1)=ipass1
fld(i,2)=-
fld(i,3)=x
fld(i,4)=y
fld(i,5)=z
fld(i,6)=finc
fld(i,7)=fdec
thet=theta(i)
fld(i,8)=thet
100 continue
c
RETURN
END
c
c
c
SUBROUTINE FIELDG (DLAT,DLONG,ALT,TM,NMX,L,X,Y,Z,F)
EQUIVALENCE (SHMIT(1,1),TG(1,1))
COMMON /NASA/ TG(50,50)
COMMON /FLDCOM/ ST,CT,SPH,CPH,R,NMAX,BT,BP,BR,B
COMMON /coeff/ gg(50,50),ggt(50,50),ggtt(50,50),jnum,knum,
> tzero,aid,mmaxn,ttemp
DIMENSION G(50,50), GT(50,50), SHMIT(50,50), GTT(50,50)
CHARACTER*60 AID,aid
DATA A/0./
c
***** FOR DOCUMENTATION OF THIS SUBROUTINE AND SUBROUTINE FIELD SEE :
C NATIONAL SPACE SCIENCE DATA CENTER'S PUBLICATION
C **COMPUTATION OF THE MAIN GEOMAGNETIC FIELD
C FROM SPHERICAL HARMONIC EXPANSIONS**
C DATA USERS' NOTE, NSSDC 68-11, MAY 1968
C GODDARD SPACE FLIGHT CENTER, GREENBELT, MD.
*****
C
C DLAT ** LATITUDE IN DEGREES POSITIVE NORTH
C DLONG ** LONGITUDE IN DEGREES POSITIVE EAST
C ALT ** ELEVATION IN KM (POSITIVE ABOVE, NEGATIVE BELOW
C EARTH'S SURFACE)
C TM ** EPOCH IN YEARS
C NMX ** SET TO INTEGER GREATER THAN DEGREE OF EXPANSION
C L ** SET TO 1 ON INITIAL DUMMY CALL, SET TO 0 ON SUBSEQUENT
C CALLS
C
C SUBROUTINE RETURNS GEOMAGNETIC FIELD DIRECTIONS (X,Y,Z), POSI-
C TIVE NORTH, EAST AND DOWN, RESPECTIVELY, AND MAGNITUDE OF TOTAL
C FIELD, F---ALL VALUES ARE IN GAMMAS
C
c----- from the data statement above, A = 0.0 only and only on the first
c call to this subroutine from anywhere within the program. after
c the first call, it is seen below that A = 6371.2 for all future
c calls during the running of the program
c
c
c TLAST=0.0
c
c IF(A.EQ.6378.139) IF(L) 210,100,110
c IF(A.EQ.6371.2) IF(L) 210,100,110
c
c A=6378.139
c A = 6371.2
c FLAT=1.-1./298.25
c FLAT = 1.
c A2=A**2
c A4=A**4
c B2=(A*FLAT)**2
c A2B2=A2*(1.-FLAT**2)
c A4B4=A4*(1.-FLAT**4)
c IF (L) 160,160,110
100 IF (TM-TLAST) 190,210,190
c
110 continue
L=0
j=jnum
k=knum
tzero=tzero
aid=aid
mmaxn=mmaxn
temp=ttemp
do 120 ii=1,maxn
  do 120 iii=1,maxn
    g(ii,iii)=gg(ii,iii)
    gt(ii,iii)=ggt(ii,iii)
    gtt(ii,iii)=ggtt(ii,iii)
120 continue
c
c 110 READ (3,260) J,K,TZERO, AID

```

```

c      L=0
c      WRITE (7,270) J,K,TZERO, AID
c      MAXN=0
c      TEMP=0.
c 120  READ (3,280) N,M,GNM,HNM,GTNM,HTNM,GTINM,HTTNM
c      WRITE (7,280) N,M,GNM,HNM,GTNM,HTNM
c      IF (N.LE.0) GO TO 130
c      MAXN=(MAX0(N,MAXN))
c      G(N,M)=GNM
c      GT(N,M)=GTNM
c      GTT(N,M)=HTTNM
c      TEMP=AMAX1 (TEMP,ABS(GTNM))
c      IF (M.EQ.1) GO TO 120
c      G(M-1,N)=HNM
c      GT(M-1,N)=HTNM
c      GTT(M-1,N)=HTTNM
c      GO TO 120
c 130  WRITE (7,290)
c 130  CONTINUE
c      DO 150 N=2,MAXN
c      DO 150 M=1,N
c      MI=M-1
c      IF (M.EQ.1) GO TO 140
c      WRITE (7,300) N,M,G(N,M),GT(N,M),GT(MI,N),GTT(N,M),GTT(
c 1   MI,N)
c      GO TO 150
c 140  WRITE (7,310) N,M,G(N,M),GT(N,M),GTT(N,M)
c 140  CONTINUE
c 150  CONTINUE
c      WRITE (7,320)
c      IF (TEMP.EQ.0.) L=-1
c      REWIND 3
c 160  IF (K.NE.0) GO TO 190
c      SHMIT(1,1)=-1.
c      DO 170 N=2,MAXN
c      SHMIT(N,1)=SHMIT(N-1,1)*FLOAT(2*N-3)/FLOAT(N-1)
c      SHMIT(1,N)=0.
c      JJ=2
c      DO 170 M=2,N
c      SHMIT(N,M)=SHMIT(N,M-1)*SQRT (FLOAT ((N-M+1)*JJ)/FLOAT (N+M-2))
c      SHMIT(M-1,N)=SHMIT(N,M)
c 170  JJ=1
c      DO 180 N=2,MAXN
c      DO 180 M=1,N
c      G(N,M)=G(N,M)*SHMIT(N,M)
c      GT(N,M)=GT(N,M)*SHMIT(N,M)
c      GTT(N,M)=GTT(N,M)*SHMIT(N,M)
c      IF (M.EQ.1) GO TO 180
c      G(M-1,N)=G(M-1,N)*SHMIT(M-1,N)
c      GT(M-1,N)=GT(M-1,N)*SHMIT(M-1,N)
c      GTT(M-1,N)=GTT(M-1,N)*SHMIT(M-1,N)
c 180  CONTINUE
c 190  T=TM-TZERO
c      DO 200 N=1,MAXN
c      DO 200 M=1,N
c      TG(N,M)=G(N,M)+T*(GT(N,M)+GTT(N,M)*T)
c      IF (M.EQ.1) GO TO 200
c      TG(M-1,N)=G(M-1,N)+T*(GT(M-1,N)+GTT(M-1,N)*T)
c 200  CONTINUE
c      TLAST=TM
c 210  DLATR=DLAT/57.2957795
c      SINLA=SIN(DLATR)
c      RLONG=DLONG/57.2957795
c      CPH=COS(RLONG)
c      SPH=SIN(RLONG)
c      IF (J.EQ.0) GO TO 220
c      R=ALT+6371.2
c      CT=SINLA
c      GO TO 230
c 220  SINLA2=SINLA**2
c      COSLA2=1.-SINLA2
c      DEN2=A2-A2B2*SINLA2
c      DEN=SQRT(DEN2)
c      FAC=(((ALT*DEN)+A2)/((ALT*DEN)+B2))**2
c      CT=SINLA/SQRT(FAC*COSLA2+SINLA2)
c      R=SQRT(ALT*(ALT+2.*DEN)+(A4-A4B4*SINLA2)/DEN2)
c 230  ST=SQRT(1.-CT**2)
c      NMX=MIN0(NMX,MAXN)
c
c      CALL FIELD
c
c      Y=BP
c      F=B
c      IF (J) 240,250,240
c 240  X=BT
c      Z=BR
c      RETURN
c
c      TRANSFORMS FIELD TO GEODETIC DIRECTIONS
c

```

```

250 SIND=SINLA*ST-SQRT(COSLA2)*CT
COSD=SQRT(1.0-SIND**2)
X--BT*COSD-BR*SIND
Z=BT*SIND-BR*COSD
RETURN
c
260 FORMAT (2I1,1X,F6.1,A60)
270 FORMAT (2I3,5X,6HEPOCH ,F7.1,5X,A60)
280 FORMAT (2I3,6F11.4)
290 FORMAT (6HO N M,6X,1HG,10X,1HH,9X,2HGT,9X,2HHT,8X,3HGT,8X,3HHT/
1)
300 FORMAT (2I3,6F11.4)
310 FORMAT (2I3,F11.4,11X,F11.4,11X,F11.4)
320 FORMAT (///)
c
END
c
c
c
SUBROUTINE FIELD
COMMON /NASA/ G(50,50)
COMMON /FLDCOM/ ST,CT,SPH,CPH,R,NMAX,BT,BP,BR,B
DIMENSION P(50,50), DP(50,50), CONST(50,50), SP(50), CP(50),
> FN(50), FM(50)
DATA P(1,1)/0./
c
IF (P(1,1).EQ.1.0) GO TO 120
P(1,1)=1.
DP(1,1)=0.
SP(1)=0.
CP(1)=1.
DO 110 N=2, nmax
FN(N)=N
DO 110 M=1,N
FM(M)=M-1
110 CONST(N,M)=FLOAT((N-2)**2-(M-1)**2)/FLOAT((2*N-3)*(2*N-5))
120 SP(2)=SPH
CP(2)=CPH
DO 130 M=3,NMAX
SP(M)=SP(2)*CP(M-1)+CP(2)*SP(M-1)
130 CP(M)=CP(2)*CP(M-1)-SP(2)*SP(M-1)
AOR=6371.2/R
AR=AOR**2
BT=0.
BP=0.
BR=0.
DO 190 N=2,NMAX
AR=AOR*AR
DO 190 M=1,N
IF (N=M) 150,140,150
140 P(N,N)=ST*P(N-1,N-1)
DP(N,N)=ST*DP(N-1,N-1)+CT*P(N-1,N-1)
GO TO 160
150 P(N,M)=CT*P(N-1,M)-CONST(N,M)*P(N-2,M)
DP(N,M)=CT*DP(N-1,M)-ST*P(N-1,M)-CONST(N,M)*DP(N-2,M)
160 PAR=P(N,M)*AR
IF (M.EQ.1) GO TO 170
TEMP=G(N,M)*CP(M)+G(M-1,N)*SP(M)
BP=BP-(G(N,M)*SP(M)-G(M-1,N)*CP(M))*FM(M)*PAR
GO TO 180
170 TEMP=G(N,M)*CP(M)
BP=BP-(G(N,M)*SP(M))*FM(M)*PAR
BT=BT+TEMP*DP(N,M)*AR
180 BR=BR-TEMP*FN(N)*PAR
BP=BP/ST
B=SQRT(BT*BT+BP*BP+BR*BR)
c
RETURN
END
c
c
c
subroutine corering (innum,idndk)
integer*4 dndkpass
common /mainfld/ fld(1500,8),dawne,dawni,duske,duski,dndkpass
common /dndkdat/ dndata(1500,26),dkdata(1500,26),
> idndata(1500,2),idkdata(1500,2)
common /thatsit/ outdawn(1500,27),outdusk(1500,27)
c
c----- subroutine description
c
this subroutine subtracts the core field at each data point and
calculates the ring current affect as defined by NASA's formula
which uses the E and I values for the entire orbit. this ring
current value is also subtracted to yield the 'residual' value.
since the total field value, the core-field value and the ring
current values are written to file, any one value can be obtained
at the next processing step.
c
NOTE: the core field subtraction is not a least squares
procedure. the least squares removal is done in
program message

```

```

c
c      pie=3.1415927
c      radius=6371.2
c
c      if (idndk .eq. 1) then
c          do 100 i=1,innum
c
c          if (dnddata(i,1) .ne. fld(i,8)) then
c              write (*,*) 'no match between latitudes in corering',
c              ' subroutine with dawn dataset'
c              write (*,*) dnddata(i,1),fld(i,8)
c              stop
c          elseif (dndkpass.ne.idndata(i,1) .or. dndkpass.ne.fld(i,1)
c              .or. idndata(i,1).ne.fld(i,1)) then
c              write (*,*) 'no match between pass numbers in corering',
c              ' subroutine with dawn dataset'
c              write (*,*) dndkpass,idndata(i,1),fld(i,1)
c              stop
c          endif
c
c          totmag=dnddata(i,8)-fld(i,2)
c          tavgmag=dnddata(i,12)-fld(i,2)
c          dip=dnddata(i,6)*(pie/180.0)
c          delbzz=(dawne*sin(dip))-(2.0*dawni*sin(dip)*
c              ((radius/dnddata(i,3))**3.0))
c          delbxx=(-1.0*dawne*cos(dip))-(dawni*cos(dip)*
c              ((radius/dnddata(i,3))**3.0))
c          ringcur=(sqrt(((fld(i,3)+delbxx)**2.0) + (fld(i,4)**2.0) +
c              ((fld(i,5)+delbzz)**2.0))) - fld(i,2)
c          resid=totmag-ringcur
c          resavgmag=tavgmag-ringcur
c          do 150 j=1,15
c              outdawn(i, j)=dnddata(i, j)
c          continue
c          do 170 j=16,21
c              jj=j-14
c              outdawn(i, jj)=fld(i, jj)
c          continue
c          outdawn(i, 22)=totmag
c          outdawn(i, 23)=tavgmag
c          outdawn(i, 24)=resid
c          outdawn(i, 25)=resavgmag
c          outdawn(i, 26)=ringcur
c          outdawn(i, 27)=dnddata(i, 26)
c
c          100      continue
c
c          elseif (idndk .eq. 2) then
c              do 200 i=1,innum
c
c              if (dkdata(i,1) .ne. fld(i,8)) then
c                  write (*,*) 'no match between latitudes in corering',
c                  ' subroutine with dusk dataset'
c                  write (*,*) dkdata(i,1),fld(i,8)
c                  stop
c              elseif (dndkpass.ne.idkdata(i,1) .or. dndkpass.ne.fld(i,1)
c                  .or. idkdata(i,1).ne.fld(i,1)) then
c                  write (*,*) 'no match between pass numbers in corering',
c                  ' subroutine with dusk dataset'
c                  write (*,*) dndkpass,idkdata(i,1),fld(i,1)
c                  stop
c              endif
c
c              totmag=dkdata(i,8)-fld(i,2)
c              tavgmag=dkdata(i,12)-fld(i,2)
c              dip=dkdata(i,6)*(pie/180.0)
c              delbzz=(duske*sin(dip))-(2.0*duski*sin(dip)*
c                  ((radius/dkdata(i,3))**3.0))
c              delbxx=(-1.0*duske*cos(dip))-(duski*cos(dip)*
c                  ((radius/dkdata(i,3))**3.0))
c              ringcur=(sqrt(((fld(i,3)+delbxx)**2.0) + (fld(i,4)**2.0) +
c                  ((fld(i,5)+delbzz)**2.0))) - fld(i,2)
c              resid=totmag-ringcur
c              resavgmag=tavgmag-ringcur
c              do 250 j=1,15
c                  outdusk(i, j)=dkdata(i, j)
c              continue
c              do 270 j=16,21
c                  jj=j-14
c                  outdusk(i, jj)=fld(i, jj)
c              continue
c              outdusk(i, 22)=totmag
c              outdusk(i, 23)=tavgmag
c              outdusk(i, 24)=resid
c              outdusk(i, 25)=resavgmag
c              outdusk(i, 26)=ringcur
c              outdusk(i, 27)=dkdata(i, 26)
c
c              200      continue
c
c          endif
c

```

```

      return
    end

c----- this is the driver for direct access

c
c      program subcore
c      real*4 rbuff(3024/4),minlat,maxlat,minlon,maxlon,
c      >      seconds(3000)
c      integer*4 ibuff(3024/4),flag1,flag2,headcnt,recnum,
c      >      outnum,dnum,dknum,
c      >      dndkpass,datacnt,stop10,stop11,
c      >      head10,data10,head11,data11,head12,data12,totrecord,
c      >      drec,dkrec,nowant(50)
c      character*80 filename
c      character*4 cbuff(3024/4)
c      character*60 aaid
c      equivalence (ibuff,rbuff),(cbuff,rbuff),(flag1,ibuff(1)),
c      >      (flag2,ibuff(2))
c      common /latlon/ minlat,maxlat,minlon,maxlon
c      common /dndkdat/ dndata(1500,26),dkdata(1500,26),
c      >      idndata(1500,2),idkdata(1500,2)
c      common /coeff/ gg(50,50),ggt(50,50),ggtt(50,50),jnum,knum,
c      >      tzero,aaid,mmaxn,ttemp
c      common /mainfld/ fld(1500,8),dawne,dawni,duske,duski,dndkpass
c      common /thatsit/ outdawn(1500,27),outdusk(1500,27)
c      COMMON /NASA/ TG(50,50)
c      COMMON /FLDCOM/ ST,CT,SPH,CPH,R,NMAX,BT,BP,BR,B
c      COMMON /magfld/ THETA(1500),PHI(1500),ELVO(1500),YEAR(1500)
c      common data(3000,26),idata(3000,2)
cc
c      write (*,*) 'INPUT FIRST DATASET FROM TAPE TO DISC TRANSFER'
c      read (*,9990) filename
c 9990 format (a80)
c      open (10, file=filename,status='old',form='unformatted',
c      >      access='DIRECT',recl=3024/4)
c      write (*,*) 'INPUT SECOND DATASET FROM TAPE TO DISC TRANSFER'
c      read (*,9990) filename
c      open (11, file=filename,status='old',form='unformatted',
c      >      access='DIRECT',recl=3024/4)
c      write (*,*) 'INPUT THIRD DATASET FROM TAPE TO DISC TRANSFER'
c      read (*,9990) filename
c      open (12, file=filename,status='old',form='unformatted',
c      >      access='DIRECT',recl=3024/4)
c      write (*,*) 'INPUT FIELD MODEL SPHERICAL HARMONIC'
c      write (*,*) 'COEFFICIENTS (GSFC1283)'
c      read (*,9990) filename
c      open (13, file=filename,status='old',form='formatted')
cc
c----- use the following if you want to input
c      your own file of nowant passes
cc      write (*,*) '1 to remove certain pass numbers'
cc      write (*,*) '0 do no remove any pass numbers'
cc      read (*,*) nocnt
cc      if (nocnt .ne. 0) then
cc          write (*,*) 'input file of pass numbers not wanted'
cc          read (*,9990) filename
cc          open (14, file=filename,status='old',form='formatted')
cc          do i=1,5000
cc              read (14,*,end=10) nowant(i)
cc          enddo
cc 10      nocnt=i-1
cc      endif
cc----- the following lines automatically place the nowant
cc      pass numbers in the nowant array. these passes are
cc      messed up for one reason or another. i'm sure they
cc      could be salvaged, but i'm lazy.
c      nowant(1)=909
c      nowant(2)=1079
c      nowant(3)=1206
c      nowant(4)=2602
c      nowant(5)=2728
c      nowant(6)=2744
c      nowant(7)=2791
c      nowant(8)=2854
c      nowant(9)=3059
c      nocnt=9
cc----- recl=116 for an ibm rs6000
c
c      write (*,*) 'OUTPUT DAWN DATA FILE OF 2-INTEGERS AND 27-REALS'
c      read (*,9990) filename
c      open (20, file=filename,form='unformatted',access='DIRECT',
c      >      recl=29)
c      write (*,*) 'OUTPUT DUSK DATA FILE OF 2-I AND 27-R'
c      read (*,9990) filename
c      open (21, file=filename,form='unformatted',access='DIRECT',
c      >      recl=29)
c      write (*,*) 'OUTPUT HEADERS FILE'
c      read (*,9990) filename
c      open (22, file=filename,form='formatted')
cc

```

```

c      write (*,*) '0 FOR NO ADDITIONAL INFORMATION'
c      write (*,*) '1 FOR ONLY Dst INDEXES'
c      write (*,*) '2 FOR COMPLETE INFORMATION... this is a big file'
c      read (*,*) info
c      if (info .gt. 0) then
c          write (*,*) 'OUTPUT ADDITIONAL INFORMATION ORBIT FILE'
c          read (*,9990) filename
c          open (23, file=filename,form='formatted')
c      endif
cc
c      write (*,*) 'MINIMUM AND MAXIMUM LATITUDE OF STUDY AREA'
c      write (*,*) 'INPUT RANGE IS FROM -90.0 TO 90.0'
c      read (*,*) minlat,maxlat
c      write (*,*) 'MINIMUM AND MAXIMUM LONGITUDE OF STUDY AREA'
c      write (*,*) 'INPUT RANGE IS FROM -180.0 TO 180.0'
c      read (*,*) minlon,maxlon
cc
cc----- the following arrays store the spherical
cc----- harmonic coefficients that describe the
cc----- core field
c      READ (13,9926) Jnum,Knum,TtZERO, AaID
c 9926 FORMAT (2I1,1X,F6.1,A60)
c      MnAXN=0
c      TTEMP=0.
c 50      READ (13,9928) N,M,GNM,HNM,GTNM,HTNM,GTINM,HTINM
c 9928 FORMAT (2I3,6F11.4)
c      IF (N.LE.0) GO TO 80
c      MnAXN=(MAX0(N,MnAXN))
c      Gg (N,M)=GNM
c      GgT (N,M)=GTNM
c      GgTT (N,M)=GTINM
c      TTEMP=AMAX1 (TTEMP,ABS(GTNM))
c      IF (M.EQ.1) GO TO 50
c      Gg (M-1,N)=HNM
c      GgT (M-1,N)=HTNM
c      GgTT (M-1,N)=HTINM
c      GO TO 50
c 80      CONTINUE
cc
c      dnrec=0
c      dkrec=0
c      totrecord=0
c      datacnt=0
c      headcnt=0
c      stop10=0
c      stop11=0
cc
c      head10=0
c      data10=0
c      recnum=1
cc
c 100      num=1
c 110      read (10,rec=recnum,err=120) rbuff
c      go to 220
cc
c 120      stop10=1
c      write (*,*) 'done with file one'
c      write (*,*) 'total headers on file one -',head10
c      write (*,*) 'total data sets on file one -',data10
c      head11=0
c      data11=0
c      totrecord=totrecord+recnum
c      recnum=1
cc----- use the go to 999 statement if you only
cc----- want to input one file at a time
c      go to 999
c 125      num=1
c 130      read (11,rec=recnum,err=150) rbuff
c      go to 220
cc
c 150      stop11=1
c      write (*,*) 'done with file two'
c      write (*,*) 'total headers on file two -',head11
c      write (*,*) 'total data sets on file two -',data11
c      head12=0
c      data12=0
c      totrecord=totrecord+recnum
c      recnum=1
c 155      num=1
c 160      read (12,rec=recnum,err=999) rbuff
cc
c 220      continue
cc----- if flag1=1 then this is header file
c      if (flag1 .eq. 1) then
c          if (info .eq. 0) then
c              go to 225
c          elseif (info .eq. 1) then
c              write (23,*) ibuff(4),(rbuff(i),i=23,34)
c          elseif (info .eq. 2) then
c              write (23,*) (ibuff(i),i=1,4),(rbuff(i),i=5,8),

```

```

c      >          (ibuff(1),i=9,10), (rbuf(1),i=11,14),
c      >          (ibuff(1),i=15,16), (rbuf(1),i=17,34),
c      >          (cbuf(1),i=35,64), (ibuff(1),i=65,67),
c      >          (rbuf(1),i=68,557)
c
c      endif
c 225  continue
c
c 8880  write (22,8880) ibuff(4), (rbuf(1),i=5,8), (ibuff(1),i=15,16)
c      format (1x,i5,4e15.7,216)
c      dndkpass=ibuff(4)
c      duske=rbuf(5)
c      duski=rbuf(6)
c      dawne=rbuf(7)
c      dawni=rbuf(8)
c      headcnt=headcnt+1
c      recnum=recnum+1
c      if (stop10 .eq. 0 .and. stop11 .eq. 0) then
c          head10=head10+1
c          go to 100
c      elseif (stop10 .eq. 1 .and. stop11 .eq. 0) then
c          head11=head11+1
c          go to 125
c      elseif (stop10 .eq. 1 .and. stop11 .eq. 1) then
c          head12=head12+1
c          go to 155
c      endif
c
c----- if flag1=2 then this is a data file
c
c 230  elseif (flag1 .eq. 2) then
c      do 230 i=num,num+29
c          idata(i,1)=ibuff(5)
c          idata(i,2)=ibuff(3)
c          xnum=real(i-num)
c          seconds(i)=(real(ibuff(4)) + (rbuf(6)*xnum))
c 230  continue
c
c----- these do 250 loops reorder the data
c----- from column to row oriented data
c
c 250  jj=7
c      do 250 j=1,25
c          do 250 i=num,num+29
c              data(i,j)=rbuf(jj)
c              jj=jj+1
c 250  continue
c
c      num=num+30
c
c----- if flag2=1 then the next record is
c----- a header and the data information is
c----- complete for this orbit
c
c 270  if (flag1 .eq. 2 .and. flag2 .eq. 1) then
c      innum=num-1
c
c----- search the nowant array for passes
c----- that just didn't happen. the
c----- following passes are doubled and
c----- are considered not wanted:
c----- 909,1079,1206,2602,2728,2744,2791,
c----- 2854,3059
c
c      do i=1,nocnt
c          if (nowant(i) .eq. idata(1,1)) then
c              write (*,*) 'removed pass number',
c              nowant(i),idata(1,1)
c      >          go to 400
c          endif
c      enddo
c
c      do 270 i=1,innum
c          data(1,26)=seconds(i)
c 270  continue
c
c      call nine (innum,outnum)
c      innum=outnum
c      call area (innum,outnum)
c      innum=outnum
c      call dawndusk (innum,dnnum,dknum)
c
c      if (dnnum .le. 0) go to 310
c      call pfligrf (dnnum,1)
c      call corering (dnnum,1)
c      do 300 i=1,dnnum
c          dnrec=dnrec+1
c          write (20,rec=dnrec) (idndata(i,j),j=1,2),
c      >          (outdawn(i,j),j=1,27)
c 300  continue
c 310  continue
c
c      if (dknum .le. 0) go to 360
c      call pfligrf (dknum,2)
c      call corering (dknum,2)
c      do 350 i=1,dknum
c          dkrec=dkrec+1
c          write (21,rec=dkrec) (idkdata(i,j),j=1,2),

```

```

c      >                               (outdusk(i,j), j=1,27)
c 350      continue
c 360      continue
c      endif
cc
c 400      recnum=recnum+1
c      datacnt=datacnt+1
c      if (stop10 .eq. 0 .and. stop11 .eq. 0) then
c          data10=data10+1
c          go to 110
c      elseif (stop10 .eq. 1 .and. stop11 .eq. 0) then
c          data11=data11+1
c          go to 130
c      elseif (stop10 .eq. 1 .and. stop11 .eq. 1) then
c          data12=data12+1
c          go to 160
c      endif
cc
c      elseif (flag1 .ne. 1 .or. flag1 .ne. 2) then
c          write (*,*) 'HOLD THE FORT MAN, BAD FIRST FLAG NUMBER'
c          write (*,*) flag1
c          go to 999
c      endif
cc
c 999  continue
c      write (*,*) 'total headers on file three -',head12
c      write (*,*) 'total data sets on file three -',data12
c      write (*,*) 'total headers on tapes -',headcnt
c      write (*,*) 'total data sets on tapes -',datacnt
c      totrecord=totrecord+recnum
c      write (*,*) 'total records read -',totrecord
c      write (*,*) 'total records written to dawn file -',dnrec
c      write (*,*) 'total records written to dusk file -',dkrec
c      close (10)
c      close (11)
c      close (12)
c      close (13)
c      close (14)
c      close (20)
c      close (21)
c      close (22)
c      close (23)
c      stop
c      end
cc
cc----- add on all subroutines from here on

```



```

program reorder
character*80 filename
integer passmjd(4000,2),idata(400,2),istore(2),
>      countall,jstop,choice,passno(4000),dndk,
>      pntcnt(4000,2),shrtpas(3000,2),shrtcnt,
>      passrec(4000,2),passrem,cnter,denum,pchoice,
>      spknum,mincheck,spkvar,nowitz(4000),outnum,
>      minchk,cntsone,inrec,innum,outrec,oif,inf,onf,
>      innumall,pntall(4000,2)
real data(400,27),dstora(27),east,west,diffwe,hilat,
>      llat,north,south,percent,totlat,upper,lower,
>      desdata(400,27),intpdata(400,27)
double precision aver(4000,2),ra(4000),cross,passavg(4000,2),
>      savglon(4000,2),cross
common data(400,27),idata(400,2)
common /order1/ aver(4000,2),passmjd(4000,2),cross
common /order2/ passno(4000),pntcnt(4000,2),pntall(4000,2)
common /order3/ savglon(4000,2),cross
common /hsort/ ra(4000)
common /shorty/ shrtpas(3000,2),shrtcnt,passrec(4000,2)
common /spike/ desdata(400,27),upper,lower,spkvar
common /intb/ intpdata(400,27)

c----- program description
c
c      this program takes data in the 2-integers and 27-reals format
c      and reorders the entire dataset into a sorted file according
c      to the variable that the user chooses. that variable is usually
c      the average longitude of each individual pass, such that after
c      reordering, the dataset will have all passes arranged from LOWEST
c      average longitude (-179.99) to the HIGHEST average longitude
c      (+179.99). if the dataset crosses the -180.0 180.0 meridian,
c      then the eastern (negative) longitudes are incremented to a
c      positive value by adding 360.0 (see write statement with
c      variable "cross"). the sorting variable can also be the
c      average elevation or the pass numbers of each individual pass
c      (sorting by pass numbers = sorting by time). this program takes
c      a little time (about 15 minutes on the DECstation 3100). the
c      program requires DIRECT ACCESS or else it just won't happen!
c      NOTE: as crazy as it may seem, real*8 is necessary for the
c      averages because i found two dusk longitude averages to be
c      EXACTLY the same with real*4. if two averages are the same
c      then passno(4000) will have the same pass twice which messes
c      up subroutine reorder2.
c      NOTE: i usually try to keep all file reads and writes in the
c      main program but reorder2 and reorder3 are a deviation
c      from the rule
c      NOTE: the dataset must be despiked and interpolated to
c      correctly calculate the longitude averages of the
c      extended passes. however, i prefer to not write out
c      the despiked or interpolated data because this program
c      represents the end of the first processing step, after-
c      which the data is ready for more involved processing
c      (ie. correlation filtering, bandpassing ...).
c      therefore, the output from reorder should be the
c      original data, only reordered. get it??
c      NOTE: for direct access on an ibm rs6000, recl=116.
c      on a dec3100, recl=29
c
c      program date: 16 apr 91
c
      write (*,*) 'INPUT 2I-27R FILE:'
      read (*,9990) filename
9990 format (a80)
      open (10, file=filename, status='old', form='unformatted',
>      access='direct', recl=116)
      write (*,*) '0 IF THIS IS A DUSK DATASET'
      write (*,*) '1 IF THIS IS A DAWN DATASET'
      read (*,*) dndk
      write (*,*) '1 TO AVERAGE AND REORDER ON LONGITUDE'
      write (*,*) '2 TO AVERAGE AND REORDER ELEVATION'
      write (*,*) '3 TO REORDER ON PASS NUMBER'
      read (*,*) choice

c      if (choice .eq. 1) then
      write (*,*) 'OUTPUT FILE OF 2I-27R DATASET REORDERED'
      read (*,9990) filename
      open (20, file=filename, form='unformatted', access='DIRECT',
>      recl=116)
      write (*,*) 'INTERMEDIATE I/O FILE NOT REORDERED'
      write (*,*) '----- DO NOT USE THIS FILE -----'
      read (*,9990) filename
      open (21, file=filename, form='unformatted', access='direct',
>      recl=116)
      endif
      if (choice .gt. 1) then
      write (*,*) 'OUTPUT FILE OF 2I-27R DATASET REORDERED'
      read (*,9990) filename
      open (20, file=filename, form='unformatted', access='direct',
>      recl=116)

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```

        endif
        write (*,*) 'OUTPUT FILE OF PASS NUMBERS AND AVERAGED',
        >           ' SORTED VARIABLE'
        read (*,9990) filename
        open (22, file=filename,form='formatted')
c
        write (*,*) '0 IF YOU WANT ALL PASSES'
        write (*,*) '1 IF SOME PASSES NEED TO BE REMOVED'
        read (*,*) pchoice
        if (pchoice .eq. 1) then
            write (*,*) 'INPUT FILE OF PASSES YOU DO NOT WANT'
            read (*,9990) filename
            open (11, file=filename,form='formatted')
        endif
        write (*,*) 'WHAT IS THE MINIMUM NUMBER OF'
        write (*,*) 'OBSERVATIONS ALLOWABLE FOR EACH PASS (50)'
        read (*,*) mincheck
c
        write (*,*) '0 FOR NO DESPIKING OF DATA SET'
        write (*,*) '1 FOR DESPIKING ONCE'
        write (*,*) '2 FOR DESPIKING TWICE (this is the usual choice)'
        write (*,*) '3 ... AND SO ON'
        read (*,*) spknum
        if (spknum .gt. 0) then
            write (*,*) 'WHAT IS THE MAXIMUM nT: (1.0)'
            write (*,*) 'WHAT IS THE MINIMUM nT: (-1.0)'
            read (*,*) upper,lower
            write (*,*) 'WHICH VARIABLE TO DESPIKE: (23)'
            write (*,*) '1-LAT, 2-LONG,...23=totavgmag..25=resavgmag...'
            write (*,*) 'lat lon rad mlt invlat diplat bs bv x y z'
            write (*,*) 'bva xa ya za totfld xfld yfld zfld inc dec'
            write (*,*) 'totmag totavgmag resid resavgmag ringcur sec'
            read (*,*) spkvar
        endif
c----- the following if statement determines if
c----- the study area includes the -180.0 180.0
c----- longitude line. for further comments see
c----- subroutine reorderl
        cross=0.0
        cross=cross
        minchk=0
        if (choice .eq. 1) then
            write (*,*) 'WESTERN MOST LONGITUDE OF STUDY AREA'
            write (*,*) 'EASTERN MOST LONGITUDE OF STUDY AREA'
            write (*,*) '-180.0 to 180.0 NOT 0.0 to 360.0'
            read (*,*) west,east
            diffwe = west - east
            if (diffwe .gt. 0.0) then
                cross=360.0
                cross=cross
                write (*,*) ' '
                write (*,*) 'the program has determined that this study'
                write (*,*) 'area crosses the 180.0, -180.0 meridian'
                write (*,*) ' '
            endif
            write (*,*) 'NORTHERN AND SOUTHERN MOST LATITUDES'
            write (*,*) '90.0 to -90.0 NOT 0.0 to 180.0'
            read (*,*) north,south
            write (*,*) 'PERCENT OF TOTAL LATITUDE LENGTH TO'
            write (*,*) 'TO BE CONSIDERED TO FIND SHORT PASSES (90.0)'
            read (*,*) percent
c----- percent is used to calculate the range that
c----- is used in subroutine shorts to determine
c----- if a pass is a short pass or a long pass.
c----- see shorts for more info. also, since no
c----- passes go below or above 83.0 degrees, the
c----- program resets north and south if needed.
        if (north .gt. 83.0) north = 83.0
        if (south .lt. -83.0) south = -83.0
        totlat=abs(north-south)
        minchk=(int(((100.0-percent)/(2*100.0))*totlat)+1)*3
        percent=((100.0-percent)/(2*100.0))*totlat
        lolat=south+percent
        hilat=north-percent
        endif
c
        if (minchk .gt. mincheck) then
            mincheck=minchk
            write (*,*) 'minimum observation cut-off increased to',
            >           ' -',mincheck
        endif
c
        if (pchoice .eq. 1) then
            do 50 kk=1,4000
                read (11,*,end=55) nowant(kk)
            continue
            continue
            pchoice=kk-1
        endif
c

```

```

c----- the main program reads the data to find
c      which 2i-27r lines belong to a specific pass
c      number (idata(n,1)) and since it reads one line
c      of the next pass it stores that line in
c      memory.
c
c      inrec=1
c      outrec=0
c      shrtcnt=0
c      countall=0
c      jstop=0
c      passrem=0
c      cntsame=0
c
c      read (10,rec=inrec) (idata(1,i),i=1,2), (data(1,j),j=1,27)
100     n=2
105     inrec=inrec+1
c      read (10,rec=inrec,err=110) (idata(n,i),i=1,2), (data(n,j),j=1,27)
c      if (idata(n,1) .ne. idata(n-1,1)) go to 120
c      n=n+1
c      go to 105
110     continue
c      jstop=1
120     continue
c      do 130 i=1,2
c      istore(i)=idata(n,1)
130     continue
c      do 140 i=1,27
c      dstore(i)=data(n,i)
140     continue
c
c      countall=countall+1
c      innum=n-1
c      innumall=innum
c
c----- if passes are NOT wanted, remove them
c      if (pchoice .eq. 0) go to 145
c      do 143 ii=1,pchoice
c          if (idata(innum,1) .eq. nowant(ii)) then
c              write (*,*) 'PASS NUMBER REMOVED ',nowant(ii),
c                         idata(innum,1)
c              passrem=passrem+1
c              go to 400
c          endif
143     continue
145     continue
c
c      if (innum .lt. mincheck) then
c          write (*,9980) idata(innum,1),innum
9980     format ('PASS REMOVED AT READ =',16,' OBSERV COUNT =',15)
c          passrem=passrem+1
c          go to 400
c      endif
c----- search for passes that cross from
c      -180.0 to 180.0 meridian
c      imerpass=idata(1,1)
c      call meridian (innum,imerpass)
c----- despike the data if user chooses and
c----- despike the number of times chosen
c
c      if (spknum .eq. 0) go to 190
c      cnter=0
150     call despike (innum,denum)
c      cnter=cnter+1
c      innum=denum
c      do 180 k=1,innum
c          do 180 kk=1,27
c              data(k,kk)=desdata(k,kk)
180     continue
c      if (cnter .lt. spknum) go to 150
c
c      190 continue
c      if (innum .lt. mincheck) then
c          write (*,9981) idata(innum,1),innum
9981     format ('PASS REMOVED AFTER DESPIKING =',16,
c                         ' OBSERV COUNT =',15)
c          passrem=passrem+1
c          go to 400
c      endif
c
c----- interpolate the dataset
c      call interp1 (dndk,innum,outnum)
c      innum=outnum
c      do 210 i=1,innum
c          do 210 j=1,27
c              data(i,j)=intpdata(i,j)
210     continue
c      if (innum .lt. mincheck) then
c          write (*,9982) idata(1,1),innum
9982     format ('PASS REMOVED AFTER INTERPOLATING =',16,
c                         ' OBSERV COUNT =',15)

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```

        passrem=passrem+1
        go to 400
    endif
c
    if (choice .eq. 1) oif=21
    if (choice .gt. 1) go to 260
    do 250 i=1,innum
        outrec=outrec+1
        write (oif,rec=outrec) (idata(1,j),j=1,2),(data(i,j),j=1,27)
250  continue
c
260  continue
    cntsome=cntsome+1
    pntcnt(cntsome,2)=innum
    pntcnt(cntsome,1)=idata(1,1)
    pntall(cntsome,1)=idata(1,1)
    pntall(cntsome,2)=innumall
c
c----- subroutine finds all short passes
    if (choice .eq. 1) call shorts (innum,hilat,lolat,dndk)
c
c----- now call reorder1 which will find
c----- the average longitude and elevation
c----- (not radius) and store them in
c----- aver(4000) as well as storing the
c----- pass number and modified julian day for
c----- the current pass.
    call reorder1 (innum,cntsome)
c----- ok, now go back and get more passes
c----- to average until done with the file
c
400  continue
    do 410 i=1,2
        idata(1,i)=istore(i)
410  continue
    do 420 i=1,27
        data(1,i)=dstore(i)
420  continue
    if (jstop .eq. 1) go to 500
    go to 100
c
500  continue
c
c----- now sort the chosen variable
    call sort (cntsome,choice)
c
    do 550 i=1,cntsome
        do 530 j=1,cntsome
            if (choice .eq. 1) then
                if (aver(j,choice) .eq. ra(i)) then
                    passno(i)=passmj(j,1)
                    passavg(i,1)=dble(passmj(j,1))
                    passavg(i,2)=aver(j,choice)
                    write (22,*) (passmj(j,ii),ii=1,2),
                                (aver(j,ii),ii=1,2)
                >           go to 540
            endif
            elseif (choice .eq. 2) then
                if (aver(j,choice) .eq. ra(i)) then
                    write (22,*) (passmj(j,ii),ii=1,2),
                                (aver(j,ii),ii=1,2)
                >           passno(i)=passmj(j,1)
                go to 540
            endif
            elseif (choice .eq. 3) then
                if (passmj(j,1) .eq. int(ra(i))) then
                    write (22,*) (passmj(j,ii),ii=1,2),
                                (aver(j,ii),ii=1,2)
                >           passno(i)=passmj(j,1)
                go to 540
            endif
        endif
530  continue
540  continue
550  continue
c
c----- now reread the file in reorder2 and write
c----- it ordered according to the pass numbers
c----- given to reorder2.
c
    if (choice .eq. 1) then
        inf=21
        onf=20
    elseif (choice .gt. 1) then
        inf=10
        onf=20
    endif
    call reorder2 (cntsome,inf,onf)
c
c----- if sorting by average longitude, then must

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```

c                                extend the shorter passes and calculate a
c                                new average.  see subroutine reorder3 for
c                                more information.
c
c      if (choice .eq. 1) then
c
c        call reorder3 (cntsome,dndk)
c
c        do 600 i=1,cntsome
c          do 610 j=1,shrtcnt
c            if (savglon(j,1) .eq. passavg(i,1)) then
c              passavg(i,2)=savglon(j,2)
c              go to 620
c            endif
c          continue
c        continue
c        ra(i)=passavg(i,2)
c      600 continue
c
c      call sort (cntsome,4)
c
c      write (22,*) ''
c      write (22,*) 'new reordering as follows'
c      write (22,*) ''
c      do 640 i=1,cntsome
c        do 650 j=1,cntsome
c          if (ra(i) .eq. passavg(j,2)) then
c            passno(i)=int(passavg(j,1))
c            do 655 k=1,cntsome
c              if (passno(i) .eq. passmjd(k,1)) then
c                i22mjd=passmjd(k,2)
c                x22elev=aver(k,2)
c                go to 656
c              endif
c            continue
c          continue
c          write (22,*) int(passavg(j,1)),i22mjd,
c                         passavg(j,2),x22elev
c          go to 660
c        endif
c      650 continue
c      660 continue
c      640 continue
c      write (22,*) ''
c      write (22,*) shrtcnt,' short passes as follows'
c      write (22,*) ''
c      do 680 i=1,shrtcnt
c        write (22,*) (shrtpas(i,j),j=1,2)
c      680 continue
c
c      call reorder2 (cntsome,10,20)
c
c      endif
c
c      999 continue
c      write (*,*) 'total passes read =',countall
c      write (*,*) 'total passes written =',cntsome
c      write (*,*) 'total passes removed =',passrem
c      write (*,*) 'total passes considered to be short =',shrtcnt
c      write (*,*) 'total records read for original input file=',inrec-1
c      close (10)
c      close (20)
c      close (21)
c      close (22)
c      close (25)
c      stop
c      end
c
c
c      subroutine meridian (innum,passnum)
c      real data(400,27)
c      integer idata(400,2),innum,passnum
c      common data(400,27),idata(400,2)
c
c      do 100 i=1,innum-1
c        if (data(i,2) .lt. data(i+1,2)) then
c          write (*,*) passnum,' CROSSES -180.0',data(i,2),data(i+1,2)
c          do 150 ii=1,innum
c            if (data(ii,2) .lt. 0.0) data(ii,2)=data(ii,2)+360.0
c          150 continue
c        go to 200
c      endif
c    100 continue
c
c    200 continue
c    return
c    end
c

```

```

c
c      subroutine reorder1 (nobs,num)
c      real data(400,27)
c      double precision nobss,along(4000),radd(4000),aalong,aavg,selev,
c      >           elev(4000),savg,aver(4000,2),cross
c      integer nobs,num,idata(400,2),passmj(4000,2),mjd,
c      >           passnum
c      common /order1/ aver(4000,2),passmj(4000,2),cross
c      common data(400,27),idata(400,2)
c
c----- subroutine description
c
c      reorder1 takes a given set of longitudes and elevations and
c      finds the average longitude and elevation for the set. since
c      some longitudes cross FROM -180.0 TO +180.0 (that is, longitudes
c      always decrease unless crossing 180) it necessary to correct
c      the average to the more usual 360 method. therefore the
c      dataset is ordered from westernmost longitude to eastern most.
c      NOTE: real*8 is necessary since on some rare occasions the
c      averages can be the same at real*4 precision.
c      NOTE: when the study area includes the -180.0 180.0 longitude
c      line (but does not include all other longitudes) it is
c      necessary to add 360.0 to the negative (or eastern)
c      longitudes so that eastern longitudes will be located after
c      the western longitudes.
c      NOTE: for datasets that are global (ie. polar datasets or the
c      whole blasted world) then variable 'west' should be input
c      as -180.0 and variable 'east' should be input as 180.0.
c      input as such will produce a map centered on 0.0
c      longitude.
c
c      nobss=dble(nobs)
c      passnum=idata(1,1)
c      mjd=idata(1,2)
c      do 50 n=1,nobs
c         along(n)=dble(data(n,2))
c         radd(n)=dble(data(n,3))
c 50  continue
c
c      aalong=0.0
c      do 110 n=1,nobs-1
c         if (along(n) .lt. along(n+1)) then
c            write (*,*) passnum,' CROSSES -180.0 to 180.0',
c            >           along(n),along(n+1)
c            go to 130
c         endif
c 110  continue
c      do 120 n=1,nobs
c         aalong=aalong+along(n)
c 120  continue
c      aavg=aalong/nobss
c      go to 150
c
c 130  aalong=0.0
c      do 135 n=1,nobs
c         if (along(n) .lt. 0.0) then
c            along(n)=along(n)+360.0
c         endif
c         aalong=aalong+along(n)
c 135  continue
c      aavg=aalong/nobss
c
c 150  continue
c      selev=0.0
c      do 170 n=1,nobs
c         elev(n)=radd(n)-6378.140
c         selev=selev+elev(n)
c 170  continue
c      savg=selev/nobss
c
c      if (aavg .gt. 180.0) aavg=aavg-360.0
c      passmj(1)=passnum
c      passmj(2)=mjd
c      aver(num,1)=aavg + cross
c      aver(num,2)=savg
c
c 200  continue
c      return
c      end
c
c
c      subroutine reorder2 (nlines,inf,onf)
c      integer nrecord(4000),passno(4000),npoints(4000),
c      >           idata(2),pntcnt(4000,2),passrec(4000,2),
c      >           shrtpas(3000,2),shrtcnt,inrec2,inf,onf,
c      >           pntall(4000,2)
c      real data(27)
c      common /order2/ passno(4000),pntcnt(4000,2),pntall(4000,2)
c      common /shorty/ shrtpas(3000,2),shrtcnt,passrec(4000,2)

```

```

c----- the basis for this subroutine was provided
c----- quite generously
c----- by: Dr. D.R.H. O'Connell
c----- Dept. of Geological Sci.
c----- Ohio State University
c
c----- determine which pass this point belongs to.
c
  if (inf .eq. 10) then
    do 20 i=1,nlines
      passrec(i,1)=passno(i)
      do 30 ii=1,nlines
        if (passno(i) .eq. pntall(ii,1)) then
          npoints(i)=pntall(ii,2)
          go to 35
        endif
    30    continue
    35    continue
    20    continue
    elseif (inf .eq. 21) then
      do 50 i=1,nlines
        passrec(i,1)=passno(i)
        do 40 ii=1,nlines
          if (passno(i) .eq. pntcnt(ii,1)) then
            npoints(i)=pntcnt(ii,2)
            go to 45
          endif
    40    continue
    45    continue
    50    continue
    endif
c
c----- npoints = number of records to allocate
c----- for each pass number. nrecord = the output file
c----- record positions for each pass
  nrecord(1)=1
  passrec(1,2)=1
  do 60 i=2,nlines
    ii=1-1
    nrecord(i)=nrecord(ii)+npoints(ii)
    passrec(i,2)=nrecord(i)
  60  continue
c----- read each data point
c
  rewind (inf)
  inrec2=0
  70  inrec2=inrec2+1
  read (inf,rec=inrec2,err=90) (idata(j),j=1,2), (data(k),k=1,27)
c----- determine the matching pass number and its
c----- output record number by searching all pass numbers
  do 80 i=1,nlines
    if (idata(1) .eq. passno(i)) then
      write (onf,rec=nrecord(i))
      .
      (idata(j),j=1,2), (data(k),k=1,27)
c----- increment output record number for this pass number
  nrecord(i)=nrecord(i)+1
c----- read next data point
  goto 70
  endif
  80  continue
  go to 70
  90  continue
c
  write (*,*) inrec2 - 1,' TOTAL RECORDS READ FOR FILE',inf
  write (*,*) nrecord(nlines)-1,' TOTAL RECORDS WRITTEN',
  >           ' FOR FILE',onf
c----- webe jammin
c
  return
  end
c
c
c----- SUBROUTINE SORT(N,choice)
double precision ra(4000),aver(4000,2),rra,cross
integer passmj(4000,2),n,choice
common /order1/ aver(4000,2),passmj(4000,2),cross
common /hsort/ ra(4000)
c-----this subroutine is written by the authors
c----- of: Numerical Recipes (fortran);
c----- The Art of Scientific Computing
c----- Cambridge University Press
c----- 1989, p. 230
c----- the routine is referred to as "heapsort"
c----- Copyright (C) 1986, 1992 Numerical Recipes Software
  if (choice .le. 2) then
    do 10 i=1,n
      ra(i)=aver(i,choice)

```

```

10      continue
      elseif (choice .eq. 3) then
        do 30 i=1,n
          ra(i)=dble(passmj(i,1))
30      continue
      endif
c
      L=N/2+1
      IR=N
100  CONTINUE
      IF (L.GT.1)THEN
        L=L-1
        RRA=RA (L)
      ELSE
        RRA=RA (IR)
        RA (IR)=RA (1)
        IR=IR-1
        IF (IR.EQ.1)THEN
          RA (1)=RRA
          RETURN
        ENDIF
      ENDIF
      I=L
      J=L+L
200  IF (J.LE.IR)THEN
      IF (J.LT.IR)THEN
        IF (RA (J).LT.RA (J+1))J=J+1
      ENDIF
      IF (RRA.LT.RA (J))THEN
        RA (I)=RA (J)
        I=J
        J=J+J
      ELSE
        J=IR+1
      ENDIF
      GO TO 200
    ENDIF
    RA (I)=RRA
    GO TO 100
  END
c
c
c
      subroutine shorts (innum,hilat,olat,dndk)
      integer innum,idata(400,2),dndk,shrtcnt,
      >          shrtpas(3000,2),passrec(4000,2)
      real data(400,27),hilat,olat
      common data(400,27),idata(400,2)
      common /shorty/ shrtpas(3000,2),shrtcnt,passrec(4000,2)
c
c----- subroutine description
c
c      shorts determines if the pass is short. a short pass is
c      a pass which does not extend above the northern-most
c      (hilat) or below the southern-most (olat).
c
      if (dndk .eq. 0) then
        if (data(1,1) .gt. olat .or.
      >          data(innum,1) .lt. hilat) then
          shrtcnt=shrtcnt+1
          shrtpas(shrtcnt,1)=idata(1,1)
          shrtpas(shrtcnt,2)=innum
        endif
      elseif (dndk .eq. 1) then
        if (data(innum,1) .gt. olat .or.
      >          data(1,1) .lt. hilat) then
          shrtcnt=shrtcnt+1
          shrtpas(shrtcnt,1)=idata(1,1)
          shrtpas(shrtcnt,2)=innum
        endif
      endif
c
      return
  end
c
c
      subroutine reorder3 (allcnt,dndk)
      integer shrtpas(3000,2),shrtcnt,passrec(4000,2),
      >          allcnt,passnum,recnum, row,recnt,rrow,frow,
      >          isdata(400,2),frec,nrec,rrec,pass,ifdata(400,2),
      >          irdata(400,2),numcnt,minrrow,stocount,minfrow,
      >          dndk,fcnt,rcnt
      real sdata(400,2),fdata(400,2),rdata(400,2),sftdat(400,2),
      >          ftdata(400,2),rtdata(400,2),totfdiff,totrdiff,
      >          fdiff,rdiff,totsrt,srtdata(400,2)
      double precision avgslon,avgrdiff,avgfdiff,savglon(4000,2),crosss
      common /shorty/ shrtpas(3000,2),shrtcnt,passrec(4000,2)
      common /trunc/ sdata(400,2),fdata(400,2),rdata(400,2),
      >          sftdat(400,2),ftdata(400,2),srtdata(400,2),
      >          rtdata(400,2)

```

```

common /order3/ savglon(4000,2),crosss
c-----subroutine description
c      this subroutine extends all short passes by adding or subtracting
c      the average longitude difference from the closest full length
c      pass, then calculates the true average longitude for the short
c      pass, and stores that true average in an array. the short passes
c      are found by subroutine shorts with a user defined percentage of total
c      length to be considered as a long pass. as this percentage is
c      increased the distance to the closest pass also increases such that
c      there is more chance for error due to a poor fit of the average
c      longitude. the closest full length pass is either west or east
c      of the short pass. if west, then the average difference is added
c      to the full length pass, however, if east then the average
c      difference is subtracted. these values are then added to the
c      longitudes of the short pass to create a set of full length
c      longitudes which are averaged together to get the true average
c      longitude. the fundamental principle involved here is that passes
c      are always parallel and do not actually cross over each other.
c      therefore, the difference between adjacent passes remains almost
c      -or at least pretty dog-gone close to almost- constant.
c
c      icnt=1
50  continue
do 100 i=1,allcnt
      if (shrtpas(icnt,1) .eq. passrec(i,1)) then
          recnum=passrec(i,2)
          passnum=passrec(i,1)
          row=shrtpas(icnt,2)
          recnt=i
          go to 200
      endif
100  continue
c----- read in the short pass
do 220 i=1,row
      read (20,rec=recnum) (isdata(i,j),j=1,2), (sdata(i,j),j=1,2)
      recnum=recnum+1
220  continue
      recnum=recnum-1
      if (passnum .ne. isdata(row,1)) then
          write (*,*) 'wrong pass number in reorder3'
          stop
      endif
c----- add 360.0 to longitudes that cross the
c      -180.0 to 180.0 meridian so that averages
c      are correct
do 230 n=1,row-1
      if (sdata(n,2) .lt. sdata(n+1,2)) then
          do 235 i=1,row
              if (sdata(i,2) .lt. 0.0) sdata(i,2)=sdata(i,2)+360.0
235      continue
              go to 238
      endif
230  continue
238  continue
c----- find the starting record number for the
c      nearest east pass
      frec=0
      numcnt=recnt+1
      if (numcnt .gt. allcnt) go to 270
      nrec=passrec(numcnt,2)
240  continue
      read (20,rec=nrec) pass
      do 260 i=1,shrtcnt
          if (pass .eq. shrtpas(i,1)) then
              numcnt=numcnt+1
              if (numcnt .gt. allcnt) go to 270
              nrec=passrec(numcnt,2)
              go to 240
          endif
260  continue
      frec=nrec
c----- find the starting record number for the
c      nearest west pass
270  continue
      rrec=0
      numcnt=recnt-1
      if (numcnt .lt. 1) go to 300
      nrec=passrec(numcnt,2)
280  continue
      read (20,rec=nrec) pass
      do 290 i=1,shrtcnt
          if (pass .eq. shrtpas(i,1)) then
              numcnt=numcnt-1
              if (numcnt .lt. 1) go to 300

```

```

nrec=passrec(numcnt,2)
go to 280
endif
290 continue
rrec=rrec
c
c----- calculate the average longitude
300 continue
avgfdiff=10000.0
if (frec .gt. 0) then
  i=1
  read (20,rec=frec,err=340) (ifdata(i,j),j=1,2),
                           (fdata(i,j),j=1,2)
  i=i+1
  freq=frec+1
320 > read (20,rec=freq,err=340) (ifdata(i,j),j=1,2),
                           (fdata(i,j),j=1,2)
  if (ifdata(i-1,1) .ne. ifdata(i,1)) go to 340
  freq=freq+1
  i=i+1
  go to 320
340 continue
frow=i-1
do 344 n=1,frow-1
  if (fdata(n,2) .lt. fdata(n+1,2)) then
    do 342 i=1,frow
      if (fdata(i,2) .lt. 0.0) fdata(i,2)=fdata(i,2)+360.0
342    continue
    go to 345
  endif
344 continue
345 continue
c----- truncate the short and forward passes
c----- to the same length
c
c     call truncate (row,frow,dndk,minfrow,stocount,passnum,
>                   ifdata(frow,1),1)
  totfdiff=0.0
  totsft=0.0
  do 350 i=1,minfrow
    fdiff=abs(sftdat(i,2)-ftdata(i,2))
    totfdiff=fdiff+totfdiff
    totsft=totsft+sftdat(i,2)
  350 continue
c----- calculate the average longitude difference
  avgfdiff=dble(totfdiff/real(minfrow))
  endif
c
c----- repeat the process for the closest west pass
  avgrdiff=10000.0
  if (rrec .gt. 0) then
    i=1
    read (20,rec=rrec) (irdata(i,j),j=1,2),(rdata(i,j),j=1,2)
    i=i+1
    rrec=rrec+1
360 > read (20,rec=rrec) (irdata(i,j),j=1,2),(rdata(i,j),j=1,2)
  if (irdata(i-1,1) .ne. irdata(i,1)) go to 380
  rrec=rrec+1
  i=i+1
  go to 360
380 continue
rrow=i-1
do 384 n=1,rrow-1
  if (rdata(n,2) .lt. rdata(n+1,2)) then
    do 382 i=1,rrow
      if (rdata(i,2) .lt. 0.0) rdata(i,2)=rdata(i,2)+360.0
382    continue
    go to 385
  endif
384 continue
385 continue
  call truncate (row,rrow,dndk,minrrow,stocount,passnum,
>                   irdata(rrow,1),-1)
  totrdiff=0.0
  totsrt=0.0
  do 390 i=1,minrrow
    rdif=abs(srtdat(i,2)-rtdata(i,2))
    totrdiff=rdif+totrdiff
    totsrt=totsrt+srtdat(i,2)
  390 continue
  avgrdiff=dble(totrdiff/real(minrrow))
  endif
c
c----- if the east difference is the smallest
c----- then use the east pass to calculate
c----- average longitude of the extended short
c----- pass
  if (avgfdiff .lt. avgrdiff) then
    do 400 i=1,frow
      if (ftdata(i,2) .eq. fdata(i,2)) then

```

```

        fcnt=1
        go to 410
    endif
400    continue
410    continue
    if (sftdat(1,2) .lt. ftdata(1,2)) then
        if (fcnt-1 .eq. 0) go to 425
        do 420 i=1,fcnt-1
            totsft=totsft+(fdata(1,2)-real(avgfdiff))
        continue
420    continue
425    continue
        if (minfrow+fcnt .eq. frow) go to 435
        do 430 i=minfrow+fcnt,frow
            totsft=totsft+(fdata(1,2)-real(avgfdiff))
        continue
430    continue
435    continue
    elseif (sftdat(1,2) .gt. ftdata(1,2)) then
        if (fcnt-1 .eq. 0) go to 445
        do 440 i=1,fcnt-1
            totsft=totsft+(fdata(1,2)+real(avgfdiff))
        continue
440    continue
445    continue
        if (minfrow+fcnt .eq. frow) go to 455
        do 450 i=minfrow+fcnt,frow
            totsft=totsft+(fdata(1,2)+real(avgfdiff))
        continue
450    continue
455    continue
    endif
    avgslon=dble(totsft)/dble(frow)

c----- repeat the process if the west pass is
c----- the closest
    elseif (avgrdiff .lt. avgfdiff) then
        do 500 i=1,rrow
            if (rtdata(1,2) .eq. rdata(i,2)) then
                rcnt=1
                go to 510
            endif
500    continue
510    continue
        if (srtdat(1,2) .lt. rtdata(1,2)) then
            if (rcnt-1 .eq. 0) go to 525
            do 520 i=1,rcnt-1
                totsrt=totsrt+(rdata(i,2)-real(avgrdiff))
            continue
520    continue
525    continue
        if (minrrow+rcnt .eq. rrow) go to 535
        do 530 i=minrrow+rcnt,rrow
            totsrt=totsrt+(rdata(i,2)-real(avgrdiff))
        continue
530    continue
535    continue
    elseif (srtdat(1,2) .gt. rtdata(1,2)) then
        if (rcnt-1 .eq. 0) go to 545
        do 540 i=1,rcnt-1
            totsrt=totsrt+(rdata(i,2)+real(avgrdiff))
        continue
540    continue
545    continue
        if (minrrow+rcnt .eq. rrow) go to 555
        do 550 i=minrrow+rcnt,rrow
            totsrt=totsrt+(rdata(i,2)+real(avgrdiff))
        continue
550    continue
555    continue
    endif
    avgslon=dble(totsrt)/dble(rrow)
endif

c-----store the average in array
    if (avgslon .gt. 180.0) avgslon = avgslon - 360.0
    savglon(icnt,1)=dble(passnum)
    savglon(icnt,2)=avgslon + crosss

icnt=icnt+1
if (icnt .gt. shrtcnt) return
go to 50

end

c
c
c
    subroutine truncate (xrow,yrow,dndk,minrow,stocount,
>                      xpassno,ypassno,fr)
    integer xrow,yrow,stocount,rows1,rowsinc,minrow,fr,
>           dndk,xpassno,ypassno
    real xdata(400,2),ydata(400,2),sftdat(400,2),ftdata(400,2),
>           adata,bdata,diffab,abss,
>           rtdata(400,2),srtdat(400,2)
    common /trunc/ sdata(400,2),fdata(400,2),rdata(400,2),
>                  sftdat(400,2),ftdata(400,2),srtdat(400,2),
>                  rtdata(400,2)
c

```

```

c----- subroutine description
c      truncate compares the input passes and truncates both
c      passes to the same overlapping length.
c
c      do 20 j=1,xrow
c          do 20 jj=1,2
c              xdata(j,jj)=sdata(j,jj)
c 20      continue
c      if (fr) 50,50,60
c 50      do 55 j=1,yrow
c          do 55 jj=1,2
c              ydata(j,jj)=rdata(j,jj)
c 55      continue
c      go to 80
c 60      do 65 j=1,yrow
c          do 65 jj=1,2
c              ydata(j,jj)=fdata(j,jj)
c 65      continue
c
c 80      continue
c      stocount=0
c      jj=1
c      rowii=xrow
c      rowinc=yrow
c----- loops from 90 to 200 increment through the
c      two input passes and truncate the lengths
c      to the same length
c 90      continue
c      adata=xdata(jj,1)
c      bdata=ydata(jj,1)
c      diffab=adata-bdata
c      abss=abs(diffab)
c      if (rowii .eq. 0 .or. rowinc .eq. 0) then
c----- if this happens, then the findgap subroutine from
c      movetrunc will have to be implemented to remove
c      the appropriate pass. so far, there hasn't been
c      any problems. another alternative would be to
c      use only the east or west pass instead of
c      comparing both to the short pass.
c
c      write (*,*) 'xrows (s) =',rowii,' yrows (',fr,') =',rowinc
c      write (*,*) 'big problem with pass number =',xpassno,ypassno
c      write (*,*) 'xrow =',xrow,' yrow =',yrow
c      stop
c      endif
c      minrow=min(rowii,rowinc)
c----- if pass a (ii) matches pass b (inc) at
c      beginning length then write to xdata and
c      ydata and race to main program
c      if (abss .lt. 0.33) then
c          if (fr .eq. -1) then
c              do 110 ll=1,minrow
c                  do 110 kk=1,2
c                      srtdata(ll,kk)=xdata(ll,kk)
c                      rtdata(ll,kk)=ydata(ll,kk)
c 110      continue
c          elseif (fr .eq. 1) then
c              do 115 ll=1,minrow
c                  do 115 kk=1,2
c                      sftdata(ll,kk)=xdata(ll,kk)
c                      ftdata(ll,kk)=ydata(ll,kk)
c 115      continue
c      endif
c      return
c      endif
c----- if pass a no matcha the b data then find new
c      a or b depending on whether or not ascending
c      or descending order of independent variable
c      if (abss .ge. 0.33) then
c          stocount=stocount+1
c----- if this is a dusk pass then will count from
c      -90.0 lat degrees toward the equator
c      if (dndk .eq. 0) then
c          if (xdata(jj,1) .gt. ydata(jj,1)) then
c              rowinc=rowinc-1
c              do 130 nn=1,rowinc
c                  do 130 kk=1,2
c                      ydata(nn,kk)=ydata(nn+1,kk)
c 130      continue
c          elseif (xdata(jj,1) .lt. ydata(jj,1)) then
c              rowii=rowii-1
c              do 150 nn=1,rowii
c                  do 150 kk=1,2
c                      xdata(nn,kk)=xdata(nn+1,kk)
c 150      continue
c      endif
c----- if this is a dawn pass then will count from
c      the equator toward the south pole
c      that is decreasing independent variable
c      elseif (dndk .eq. 1) then

```

```

        if (xdata(jj,1) .lt. ydata(jj,1)) then
          rowinc=rowinc-1
          do 160 mm=1, rowinc
            do 160 kk=1,2
              ydata(mm,kk)=ydata(mm+1,kk)
            continue
160      elseif (xdata(jj,1) .gt. ydata(jj,1)) then
          rowii=rowii-1
          do 170 nn=1, rowii
            do 170 kk=1,2
              xdata(nn,kk)=xdata(nn+1,kk)
            continue
170      endif
      endif
    endif
  go to 90
end
c
c
c
c
c subroutine interp1 (dndk,num,ii)
real data(400,27),xdata(27),intpdata(400,27)
integer num,idata(400,2),dndk
common data(400,27),idata(400,2)
common /inta/ xdata(27)
common /intb/ intpdata(400,27)
c----- subroutine description
c
c the basic concept of this subroutine was provided by:
c      Dr. D.N. "Tiku" Ravat
c      Dept. of Geology
c      Purdue University
c this subroutine linearly interpolates ALL 27-r variables by
c basing the interpolation on the latitudes which are interpolated
c at every 0.33 degrees of starting latitude.
c
ii=0
xlat=real(int(data(1,1)*100.0))/100.0
if (dndk .eq. 0) then
  if (xlat .lt. data(1,1)) xlat=xlat + 0.33
  i=1
100  if (xlat.ge.data(i,1) .and. xlat.le.data(i+1,1)) then
    call interp2 (i,xlat)
    xdata(2)=real(int(xdata(2)*100.0))/100.0
    ii=ii+1
    do 150 j=1,27
      intpdata(ii,j)=xdata(j)
    continue
    xlat=xlat + 0.33
    if (xlat .gt. data(num,1)) return
    go to 100
  elseif (xlat .gt. data(i+1,1)) then
    i=i+1
    go to 100
  endif
c
  elseif (dndk .eq. 1) then
    if (xlat .gt. data(1,1)) xlat=xlat - 0.33
    i=1
180  if (xlat.le.data(i,1) .and. xlat.ge.data(i+1,1)) then
    call interp2 (i,xlat)
    xdata(2)=real(int(xdata(2)*100.0))/100.0
    ii=ii+1
    do 200 j=1,27
      intpdata(ii,j)=xdata(j)
    continue
    xlat=xlat - 0.33
    if (xlat .lt. data(num,1)) return
    go to 180
  elseif (xlat .lt. data(i+1,1)) then
    i=i+1
    go to 180
  endif
endif
end
c
c
c subroutine interp2 (inum,xlat)
real data(400,27),diffdata(27),xdata(27)
integer inum,idata(400,2)
common data(400,27),idata(400,2)
common /inta/ xdata(27)
c----- this subroutine is also from Tiku and is

```

```

c          the interpolator (not to confused with the
c          terminator!)
c
c          do 100 i=1,27
c             diffdata(i)=data(inum,i)-data(inum+1,i)
c          continue
c          do 120 i=1,27
c             xdata(i)=data(inum,i)+(xlat-data(inum,i))*  

c             >          (diffdata(i)/diffdata(i))
c          continue
c
c          return
c          end
c
c
c          subroutine despike (npts,outnum)
c          real data(400,27),desdata(400,27),upper,lower
c          integer ic(400),outnum,var,idata(400,2)
c          common data(400,27),idata(400,2)
c          common /spike/ desdata(400,27),upper,lower,var
c
c----- this subroutine also provided by Tiku
c
c
c          PROGRAM DESPIKE
c*****  

c          PROGRAM DESPIKE REMOVES MOST SPIKES FROM THE INPUT DATA SET.
c          HOWEVER, FOR BEST RESULTS, IT IS SUGGESTED TO RUN DESPIKE
c          AT LEAST THREE TIMES --- FOR EXAMPLE:
c
c          INPUT1 ---DESPIKE---> OUTPUT1
c          (OUTPUT1 - INPUT2) ---DESPIKE---> OUTPUT2
c          (OUTPUT2 - INPUT3) ---DESPIKE---> OUTPUT3.
c
c          STILL, AFTER RUNNING DESPIKE THREE TIMES, IT FAILS TO ELIMINATE
c          ORBITS WITH DISCONTINUOUS RESID VS LATITUDE PROFILES.
c          PROGRAM DEGAP ATTEMPTS TO TAKE CARE OF SUCH PASSES.
c
c
c          PARAMETERS TO CHECK: "UPPER" AND "LOWER" (IN NANOTESLAS):
c
c          IF PROGRAM DESPIKE HAS DETERMINED OBSERVATION N TO BE
c          A GOOD POINT, IT THEN SETS OUT TO DETERMINE IF POINT N+1
c          IS A GOOD POINT. IT DOES THIS BY CHECKING THE POINTS
c          N, N+1, AND N+2. OBSERVATION N+1 WILL BE A GOOD POINT
c          IF THE RESIDUAL DIFFERENCE BETWEEN POINT N+1 AND THE
c          POINT ABOVE IT (N OR N+2) IS LESS THAN "UPPER" AND
c          IF THE RESIDUAL DIFFERENCE BETWEEN IT AND THE POINT
c          BELOW IT (N+2 OR N) IS GREATER THAN "LOWER".
c*****  

c
c          DO 2 I=1,400
c             IC(I)=1
c          2 CONTINUE
c
c*****  

c          ARE THE FIRST NEW POINTS SPIKES?
c          NOTE: DATA(U,23) = RESID2(U)
c
c          I=1
c          15 SL1=(DATA(I+1,var)-DATA(I,var))
c             SL2=(DATA(I+2,var)-DATA(I,var))
c             SL3=(DATA(I+3,var)-DATA(I,var))
c             SL4=(DATA(I+4,var)-DATA(I,var))
c             XSL=ABS(SL1+SL2+SL3+SL4)/4.0
c
c             S2=(DATA(I+2,var)-DATA(I+1,var))
c
c             IF(ABS(SL1).GT.(3.0*XSL).OR.ABS(SL1).GT.(ABS(3.0*S2))) IC(I)=0
c             IF(IC(I).EQ.0) THEN
c               I=I+1
c               GO TO 15
c             ENDIF
c
c*****  

c          ARE THE MID POINTS SPIKES?
c
c          DO 20 J=I,NPTS-2
c             SL2=(DATA(J+1,var)-DATA(J+2,var))
c             IF(SL1.GT.UPPER.AND.SL2.LT.LOWER) IC(J+1)=0
c             IF(SL1.LT.LOWER.AND.SL2.GT.UPPER) IC(J+1)=0
c             SL1=SL2
c          20 CONTINUE
c
c*****  

c          IS THE LAST POINT A SPIKE?
c
c          K=NPTS-2
c          25 IF(IC(K).EQ.0) THEN
c             K=K-1

```

```

      GO TO 25
      ENDIF
C
      SL1=ABS(DATA (K,var)-DATA (NPTS-1,var))
      SL2=ABS(DATA (NPTS-1,var)-DATA (NPTS,var))
      SL3=ABS(DATA (K,var)-DATA (NPTS,var))
      IF (IC(NPTS-1).EQ.0) THEN
        IF (SL1.GT.(3.0*SL2)) IC(NPTS)=0
        IF (SL3.GT.(3.0*UPPER)) IC(NPTS)=0
      ENDIF
      IF (IC(NPTS-1).EQ.1) THEN
        IF (SL2.GT.(3.0*SL1)) IC(NPTS)=0
      ENDIF
C
      NOBS=0
C      DO 30 I=1,NPTS
C        IF (IC(I).EQ.1) NOBS=NOBS+1
C 30  CONTINUE
C      WRITE(6,*) IDATA(1,1), NOBS
C
      outnum=0
      DO 35 I=1,NPTS
        IF (IC(I).EQ.1) THEN
          outnum=outnum+1
          do 32 m=1,27
            desdata(outnum,m)=data (I,m)
            continue
        ENDIF
35    CONTINUE
C
      return
      END

```



```

program message
character*80 filename
character*10 dndx
real data(400,27),intpdata(400,27),movdata(400,27),
>      dstore(27),desdata(400,27),upper,lower,mean,
>      varmax,mincc,strintdat(400)
integer idata(400,2),countall,innum,outnum,winlen2,incwen2,
>      istore(2),denum,cnter,spknum,spkvar,movvar,choice,
>      vary,nowant(4000),col,eight,zero,gfchoice,
>      col3,mincheck,gftype,passrem,recnum,gfcnt,winlen1,
>      winlen2a,winlen2b
common data(400,27)
common /intb/ intpdata(400,27)
common /move/ movdata(400,27),winlen2,incwen2,movvar,gftype,
>      varmax,mincc,incwen1,winlen1,winlen2a,winlen2b
common /spike/ desdata(400,27),upper,lower,spkvar
common /trax/ x(400),y(400)
c
c----- program description
c
c      ok, first the name of the program.  to be frank, i just couldn't
c      think of shortened name for despiking-moving-average-min-max-
c      cubic-spline-linear-interpolation... so i just called the
c      program "massage" because this program massages the data a bit!!
c      this program takes data in the 2-integers and 27-reals format
c      and after a bit of work writes the worked over data in either
c      21-27r or the more usual format of a file of latitudes, longitudes
c      and radii separated by headers and a file of residuals separated
c      by headers.  the bit of work includes, 1) removing bad data points
c      characterized by a large change in magnitude from surrounding
c      data points. ie: removing "spikes". 2) fitting a moving average
c      to the despiked dataset. 3) interpolating every 0.33 degrees of
c      latitude on the moving average (guide function). 4) interpolating
c      the despiked dataset. interpolating schemes are linear for
c      the initial run through on a pass, then the gf is a spline.
c      5) fit and remove a least squares core field from the data.
c      of course there are several variations on the above scheme which
c      can be figured out by reading the write (*,*) statements.
c      NOTE: if certain passes are NOT wanted, this program will
c      remove them from the processing.
c      NOTE: i've found that the bandpass filter works better than
c      removing a guide function or cubic spline, but u can
c      do as u like.
c      NOTE: for optimal results, make use of the least squares
c      core field removal as applied by massage.
c      NOTE: for ibm rs6000, recl=116. for dec3100, recl=29
c
c      program date: 16 apr 91
c
      write (*,*) 'INPUT 2I-27R FILE'
      read (*,9990) filename
9990 format (a80)
      open (10, file=filename,status='old',form='unformatted',
>            access='direct',recl=116)
c
      write (*,*) 'TYPE dawn OR dusk AS APPROPRIATE'
      read (*,9991) dndx
9991 format (a10)
c
      write (*,*) '0 IF YOU WANT ALL PASSES'
      write (*,*) '1 IF CERTAIN PASSES NEED TO BE REMOVED'
      read (*,*) choice
      if (choice .eq. 1) then
        write (*,*) 'INPUT FILE OF PASSES YOU DO NOT WANT'
        read (*,9990) filename
        open (11, file=filename,status='old',form='formatted')
      endif
c
      write (*,*) '0 FOR CUBIC SPLINE AND DATA OUTPUT'
      write (*,*) '1 FOR ONLY CUBIC SPLINE OUTPUT'
      write (*,*) '2 FOR ONLY DATA OUTPUT (the usual choice)'
      read (*,*) gfchoice
      write (*,*) 'WHICH 27R VARIABLE TO BE WRITTEN TO FILE(S) (12)'
      write (*,*) '1=LAT, 2=LONG ,..12=bva,...23=totavgmag'
      write (*,*) 'lat lon rad mit invlat diplat bs bv x y z'
      write (*,*) 'bva ya za totfld xfld yfld zfld inc dec'
      write (*,*) 'totmag totavgmag resid resavgmag ringcur sec'
      write (*,*) '0 IF YOU WANT 2I-27R OUTPUT'
      read (*,*) vary
      write (*,*) '1 FIT LEAST SQUARES CORE FIELD TO THIS VARIABLE'
      write (*,*) '0 DO NOT FIT CORE FIELD'
      write (*,*) 'choose 1'
      read (*,*) ixfit
      if (ixfit .eq. 1) then
        write (*,*) 'OUTPUT FILE FOR PASS NUMBERS AND X VALUES'
        read (*,9990) filename
        open (22, file=filename, form='formatted')
      endif
c
      if (gfchoice .eq. 0 .or. gfchoice .eq. 2) then

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```

if (vary .eq. 0) then
  write (*,*) 'OUTPUT 2I-27R DATA FILE'
  read (*,9990) filename
  open (20, file=filename,form='unformatted')
endif
if (vary .gt. 0) then
  write (*,*) 'OUTPUT DATA FILE OF HEADERS AND VARIABLE'
  read (*,9990) filename
  open (20, file=filename,form='unformatted')
  write (*,*) 'OUTPUT DATA FILE OF HEADERS'
  write (*,*) 'AND INTERP-LATS,LONGS,RADI'
  read (*,9990) filename
  open (21, file=filename,form='unformatted')
endif
endif
c
20  continue
write (*,*) '0 FOR NO DESPIKING OF DATA SET'
write (*,*) '1 FOR DESPIKING ONCE'
write (*,*) '2 FOR DESPIKING TWICE (this is the usual choice)'
write (*,*) '3 ... AND SO ON'
read (*,*) spknum
if (spknum .gt. 0) then
  write (*,*) 'WHAT IS THE MAXIMUM nT: (1.0)'
  write (*,*) 'WHAT IS THE MINIMUM nT: (-1.0)'
  read (*,*) upper,lower
  write (*,*) 'WHICH VARIABLE TO DESPIKE: (23)'
  write (*,*) '1-LAT, 2-LONG,...12-bva,...23=totavgmag'
  write (*,*) 'lat lon rad mlt invlat diplat bs bv x y z'
  write (*,*) 'bva xa ya za totfld xfld yfld zfld inc dec'
  write (*,*) 'totmag totavgmag resid resavgmag ringcur sec'
  read (*,*) spkvar
endif
c
if (gfchoice .lt. 2) then
  write (*,*) 'WHICH VARIABLE TO WORK WITH IN CUBIC SPLINE: (12)'
  write (*,*) '1-LAT, 2-LONG,...12-bva,...23=totavgmag'
  write (*,*) 'lat lon rad mlt invlat diplat bs bv x y z'
  write (*,*) 'bva xa ya za totfld xfld yfld zfld inc dec'
  write (*,*) 'totmag totavgmag resid resavgmag ringcur sec'
  read (*,*) movvar
  if (vary .eq. 0) then
    write (*,*) 'OUTPUT 2I-27R CUBIC SPLINE FILE'
    read (*,9990) filename
    open (23, file=filename,form='unformatted')
  endif
  if (vary .gt. 0) then
    write (*,*) 'OUTPUT FILE OF CUBIC SPLINE VARIABLE'
    read (*,9990) filename
    open (23, file=filename,form='unformatted')
    write (*,*) 'OUTPUT FILE OF CUBIC SPLINE HEADERS AND'
    write (*,*) 'AND INTERP-LATS,LONGS,RADI'
    read (*,9990) filename
    open (24, file=filename,form='unformatted')
    write (*,*) 'OUTPUT FILE OF DATA - CUBIC SPLINE'
    read (*,9990) filename
    open (28, file=filename,form='unformatted')
  endif
  write (*,*) 'OUTPUT STATISTICS FILE'
  read (*,9990) filename
  open (25, file=filename,form='formatted')
  write (25,*) 'PASS      VAR      STDEV      MIN      MEAN      MAX'
  write (*,*) 'OUTPUT FILE OF TRACKS FITTED WITH A CUBIC SPLINE'
  read (*,9990) filename
  open (26, file=filename,form='unformatted')
  write (*,*) 'OUTPUT FILE OF TRACKS NOT FITTED'
  read (*,9990) filename
  open (27, file=filename,form='unformatted')
  write (*,*) 'TYPE OF CUBIC SPLINE TO APPLY TO DATA: (2)'
  write (*,*) '1 FOR A MOVING AVERAGE'
  write (*,*) '2 FOR A MIN-MAX-AVERAGE FINDER'
  read (*,*) gftype
  if (gftype .eq. 1) then
    incwen2=0
    winlen2=0
    winlen2a=0
    winlen2b=0
    write (*,*) 'WHAT IS THE LENGTH OF THE WINDOW:'
    read (*,*) winlen1
    write (*,*) 'HOW MANY POINTS TO INCREMENT WINDOW LOCATION:'
    write (*,*) 'should be equal to or greater than 1'
    read (*,*) incwen1
  elseif (gftype .eq. 2) then
    write (*,*) 'LENGTH OF THE first AVERAGING WINDOW:'
    read (*,*) winlen2a
    write (*,*) 'LENGTH OF THE min-max AVERAGING WINDOW:'
    read (*,*) winlen2
    write (*,*) 'LENGTH OF THE last AVERAGING WINDOW:'
    read (*,*) winlen2b
    write (*,*) 'HOW MANY POINTS TO SEARCH FROM AN ENDPOINT TO FIND'
  endif

```

```

write (*,*) 'IF THE MIN OR MAX POINT SHOULD BE REMOVED'
read (*,*) incwen2
write (*,*) 'IF MINCC CAN NOT BE MATCHED THEN'
write (*,*) 'WHAT IS THE LENGTH OF THE AVERAGING WINDOW'
read (*,*) winlen
write (*,*) 'IF MINCC CAN NOT BE MATCHED THEN'
write (*,*) 'HOW MANY POINTS TO INCREMENT WINDOW LOCATION:'
write (*,*) 'should be equal to or greater than 1'
read (*,*) incwen1
endif
write (*,*) 'MAXIMUM VARIANCE WITHOUT FITTING A CUBIC SPLINE'
read (*,*) varmax
write (*,*) 'MINIMUM CORRELATION COEFFICIENT OF CUBIC SPLINE TO'
write (*,*) 'ORIGINAL DATA'
read (*,*) mincc
endif
write (*,*) 'AND FINALLY - WHAT IS THE MINIMUM NUMBER OF'
write (*,*) 'OBSERVATIONS ALLOWABLE FOR EACH PASS (50)'
read (*,*) mincheck
c
if (choice .eq. 1) then
  do 50 kk=1,4000
    read (11,*,end=55) nowant(kk)
  50  continue
  55  continue
  choice=kk-1
endif
c
c----- read the data and find all lines
c----- for each individual pass
noc=0
nocgf=0
gfcnt=0
itercnt=0
passrem=0
countall=0
jstop=0
ifirstcnt=0
iseccnt=0
lendcnt=0
i3cnt=0
i4cnt=0
i5cnt=0
i6cnt=0
i7cnt=0
i8cnt=0
ibigcnt=0
iswitch=0
ilowcnt=0
recnum=1
read (10,rec=recnum) (idata(1,i),i=1,2), (data(1,j),j=1,27)
100 n=2
105 recnum=recnum+1
read (10,rec=recnum,err=110) (idata(n,i),i=1,2), (data(n,j),j=1,27)
if (idata(n,1) .ne. idata(n-1,1)) go to 120
n=n+1
go to 105
110 continue
jstop=1
120 continue
do 130 i=1,2

istore(1)=idata(n,1)
130 continue
do 140 i=1,27
  dstore(i)=data(n,i)
140 continue
c
countall=countall+1
c----- if passes are NOT wanted, remove them
if (choice .eq. 0) go to 145
do 63 ii=1,choice
  if (idata(1,1) .eq. nowant(ii)) then
    write (*,*) 'PASS NUMBER REMOVED ',nowant(ii),idata(1,1)
    passrem=passrem+1
    go to 400
  endif
63 continue
145 continue
c
innum=n-1
c
if (innum .lt. mincheck) then
  write (*,9980) idata(1,1),innum
9980  format ('PASS REMOVED AT READ =',i6,' OBSERV COUNT =',i5)
  passrem=passrem+1
  go to 400
endif
c----- search for passes that cross the
c----- -180.0 180.0 meridian

```

```

      call meridian (innum)
c----- despike the data if user chooses and
c----- despike the number of times chosen
      if (spknum .eq. 0) go to 190
      cnter=0
150  call despike (innum,denum)
      cnter=cnter+1
      innum=denum
      do 180 k=1,innum
          do 180 kk=1,27
              data(k,kk)=desdata(k,kk)
180  continue
      if (cnter .lt. spknum) go to 150
c----- continue
      if (innum .lt. mincheck) then
          write (*,9981) idata(1,1),innum
9981  format ('PASS REMOVED AFTER DESPIKING =',16,
>           ' OBSERV COUNT =',15)
          passrem=passrem+1
          go to 400
      endif
c----- interpolate the dataset
      call interpl (dndk,innum,outnum)
      innum=outnum
      if (innum .lt. mincheck) then
          write (*,9982) idata(1,1),innum
9982  format ('PASS REMOVED AFTER INTERPOLATING =',16,
>           ' OBSERV COUNT =',15)
          passrem=passrem+1
          go to 400
      endif
c----- do 205 i=1,innum
      x(1)=intpdata(i,1)
      y(1)=intpdata(i,2)
205  continue
c----- fit the core field (#16) profile to
c----- the chosen variable profile
      if (ixfit .eq. 1) then
          call srfit(innum,xxx,vary)
          write (22,*) idata(1,1),xxx
      endif
c----- if (gfchoice .eq. 1) go to 300
      if (vary .eq. 0) go to 230
      col=1
      col3=3
      zero=0
      mean=0.0
      eight=8888
      write (20) outnum,col,zero,mean,idata(1,1),eight
      write (21) outnum,col3,zero,mean,idata(1,1),eight
      do 210 m=1,outnum
          if (intpdata(m,2).gt.180.0) intpdata(m,2)=intpdata(m,2)-360.0
          write (20) intpdata(m,vary)
          write (21) intpdata(m,1),intpdata(m,2),intpdata(m,3)
          strintdat(m)=intpdata(m,vary)
210  continue
230  if (vary .gt. 0) go to 300
      do 250 i=1,outnum
          if (intpdata(i,2).gt.180.0) intpdata(i,2)=intpdata(i,2)-360.0
          write (20) (idata(i,j),j=1,2),(intpdata(i,j),j=1,27)
250  continue
c----- this if statement if chosen, will fit
c----- the cubic spline, interpolate it and
c----- write it to file
300  continue
      if (gfchoice .lt. 2) then
          do 310 k=1,innum
              do 310 kk=1,27
                  data(k,kk)=intpdata(k,kk)
310  continue
      call moving (innum,num,idata(1,1),eight,gfcnt,dndk,itercnt,
>           ifirstcnt,iseccnt,iendcnt,i3cnt,i4cnt,i5cnt,
>           i6cnt,i7cnt,i8cnt,ibigcnt,iswitch,ilowcnt)
      outnum=innum
      if (eight .eq. 7777) call track (27,innum,noc,nocgf)
      if (vary .gt. 0) then
          col=1
          col3=3
          zero=0
          mean=0.0

```

```

if (eight .eq. 8888) then
  write (28) outnum,col,zero,mean,idata(1,1),eight
  write (23) outnum,col,zero,mean,idata(1,1),eight
  write (24) outnum,col3,zero,mean,idata(1,1),eight

  do m=1,outnum
    write (28) (strintdat(m)-intpdata(m,vary))
  enddo
  elseif (eight .eq. 7777) then
    ieight=8888
    write (28) outnum,col,zero,mean,idata(1,1),ieight
    write (23) zero,col,zero,mean,idata(1,1),eight
    write (24) zero,col3,zero,mean,idata(1,1),eight
    do m=1,outnum
      write (28) strintdat(m)
    enddo
    go to 400
  endif
c
c      call track (26,outnum,noc,nocgf)
c
  do 350 m=1,outnum
    if (intpdata(i,2).gt.180.0)
      intpdata(i,2)=intpdata(i,2)-360.0
    write (23) intpdata(m,vary)
    write (24) intpdata(m,1),intpdata(m,2),intpdata(m,3)
  350  continue
  endif
  if (vary .eq. 0) then
    if (eight .eq. 7777) then
      write (23) eight
      go to 400
    endif
c
c      call track (26,outnum,noc,nocgf)
c
  do 370 m=1,outnum
    if (intpdata(i,2).gt.180.0)
      intpdata(i,2)=intpdata(i,2)-360.0
    >      write (23) (idata(i,mm),mm=1,2),
      >          (intpdata(m,mm),mm=1,27)
  370  continue
  endif
  endif
c----- set idata(1,1) and data(1,1) to the
c----- previously read values and go back and
c----- get the rest of the values for the pass
  400 continue
  do 410 i=1,2
    idata(1,1)=istore(i)
  410  continue
  do 420 i=1,27
    data(1,1)=dstore(i)
  420  continue
  if (jstop .eq. 1) go to 999
  go to 100
c
  999 continue
  write (*,*) 'records read =',recnum-1
  write (*,*) 'passes read =',countall
  write (*,*) 'passes removed =',passrem
  write (*,*) 'passes fitted with a cubic spline =',gfcnt
  write (*,*) 'passes without a cubic spline =',
  >          countall-gfcnt-passrem
  write (*,*) 'total extra iterations =',itercnt-gfcnt
  if (gfctype .eq. 2) then
    write (*,*) 'ifirstcnt,' first points were removed'
    write (*,*) 'iseccnt,' second points were removed'
    write (*,*) 'iswitch,' orbits used a moving-average gf'
  endif
  write (*,*) iendcnt,' passes were 2nd order'
  write (*,*) i3cnt,' passes were 3rd order'
  write (*,*) i4cnt,' passes were 4th order'
  write (*,*) i5cnt,' passes were 5th order'
  write (*,*) i6cnt,' passes were 6th order'
  write (*,*) i7cnt,' passes were 7th order'
  write (*,*) i8cnt,' passes were 8th order'
  write (*,*) ibigcnt,' passes were larger than 8th order'
  write (*,*) ilowcnt,' passes were below cc of',mincc
  close (10)
  close (11)
  close (20)
  close (21)
  close (23)
  close (24)
  close (25)
  close (26)
  close (27)
  stop

```

```

      end
c
c
c      subroutine meridian (innum)
real data(400,27)
integer innum
common data(400,27)
c----- subroutine description
c      this subroutine determines if a pass crosses the -180.0 180.0
c      meridian. if a pass does cross, then 360.0 is added to the
c      negative values so that the interpolation scheme does not
c      try to interpolate from -180.0 to 180.0 every 0.33 degrees
c
      do 100 i=1,innum-1
         if (data(i,2) .lt. data(i+1,2)) then
            do 150 ii=1,innum
               if (data(ii,2) .lt. 0.0) data(ii,2)=data(ii,2)+360.0
150      continue
            go to 200
         endif
100   continue
c
200   continue
      return
      end
c
c
c      subroutine interp1 (dndk,num,ii)
real data(400,27),xdata(27),intpdata(400,27)
integer num
character*10 dndk
common data(400,27)
common /inta/ xdata(27)
common /intb/ intpdata(400,27)
c----- subroutine description
c
c      the basic concept of this subroutine was provided by:
c          Dr. D.N. "Tiku" Ravat
c          Dept. of Geology
c          Purdue University
c      this subroutine linearly interpolates ALL 27-r variables by
c      basing the interpolation on the latitudes which are interpolated
c      at every 0.33 degrees of starting latitude.
c
      ii=0
      xlat=real(int(data(1,1)*100.0))/100.0
      if (dndk .eq. 'dusk') then
         if (xlat .lt. data(1,1)) xlat=xlat + 0.33
         i=1
100   if (xlat.ge.data(i,1) .and. xlat.le.data(i+1,1)) then
         call interp2 (i,xlat)
         xdata(2)=real(int(xdata(2)*100.0))/100.0
         ii=ii+1
         do 150 j=1,27
            intpdata(ii,j)=xdata(j)
            continue
         xlat=xlat + 0.33
         if (xlat .gt. data(num,1)) return
         go to 100
         elseif (xlat .gt. data(i+1,1)) then
            i=i+1
            go to 100
         endif
c
         elseif (dndk .eq. 'dawn') then
            if (xlat .gt. data(i,1)) xlat=xlat - 0.33
            i=1
180   if (xlat.le.data(i,1) .and. xlat.ge.data(i+1,1)) then
         call interp2 (i,xlat)
         xdata(2)=real(int(xdata(2)*100.0))/100.0
         ii=ii+1
         do 200 j=1,27
            intpdata(ii,j)=xdata(j)
            continue
         xlat=xlat - 0.33
         if (xlat .lt. data(num,1)) return
         go to 180
         elseif (xlat .lt. data(i+1,1)) then
            i=i+1
            go to 180
         endif
      endif
c
      end
c
c

```

```

c
c      subroutine interp2 (inum,xlat)
c      real data(400,27),diffdata(27),xdata(27)
c      integer inum
c      common data(400,27)
c      common /inta/ xdata(27)
c
c----- this subroutine is also from Tiku and is
c----- the interpolator (not to confused with the
c----- terminator!)
c
c      do 100 i=1,27
c         diffdata(i)=data(inum,i)-data(inum+1,i)
c 100   continue
c      do 120 i=1,27
c         xdata(i)=data(inum,i)+(xlat-data(inum,i))* 
c         >          (diffdata(i)/diffdata(i))
c 120   continue
c
c      return
c      end
c
c
c      SUBROUTINE SPLINE(X,Y,N,YP1,YPN,Y2)
c      PARAMETER (NMAX=100)
c      DIMENSION X(N),Y(N),Y2(N),U(NMAX)
c
c----- subroutine description
c      this subroutine provided by the authors of Numerical Recipes
c          Numerical Recipes (fortran)
c          The Art of Scientific Computing
c          Cambridge University Press, 1989
c
c      Copyright (C) 1986, 1992 Numerical Recipes Software
c      IF (YP1.GT..99E30) THEN
c          Y2(1)=0.
c          U(1)=0.
c      ELSE
c          Y2(1)=-0.5
c          U(1)=(3./X(2)-X(1))*((Y(2)-Y(1))/(X(2)-X(1))-YP1)
c      ENDIF
c      DO 11 I=2,N-1
c          SIG=(X(I)-X(I-1))/(X(I+1)-X(I-1))
c          P=SIG*Y2(I-1)+2.
c          Y2(I)=(SIG-1.)/P
c          U(I)=(6.*((Y(I+1)-Y(I))/(X(I+1)-X(I))-(Y(I)-Y(I-1))
c          &           /(X(I)-X(I-1)))/(X(I+1)-X(I-1))-SIG*U(I-1))/P
c 11    CONTINUE
c      IF (YPN.GT..99E30) THEN
c          QN=0.
c          UN=0.
c      ELSE
c          QN=0.5
c          UN=(3./ (X(N)-X(N-1)))*(YPN-(Y(N)-Y(N-1))/(X(N)-X(N-1)))
c      ENDIF
c      Y2(N)=(UN-QN*U(N-1))/(QN*Y2(N-1)+1.)
c      DO 12 K=N-1,1,-1
c          Y2(K)=Y2(K)*Y2(K+1)+U(K)
c 12    CONTINUE
c      RETURN
c      END
c
c
c      SUBROUTINE SPLINT(XA,YA,Y2A,N,X,Y)
c      DIMENSION XA(N),YA(N),Y2A(N)
c----- subroutine description
c      Copyright (C) 1986, 1992 Numerical Recipes Software
c      KLO=1
c      KHI=N
c 1    IF (KHI-KLO.GT.1) THEN
c          K=(KHI+KLO)/2
c          IF (XA(K).GT.X) THEN
c              KHI=K
c          ELSE
c              KLO=K
c          ENDIF
c          GOTO 1
c      ENDIF
c      H=XA(KHI)-XA(KLO)
c      IF (H.EQ.0.) PAUSE 'Bad XA input.'
c      A=(XA(KHI)-X)/H
c      B=(X-XA(KLO))/H
c      Y=A*YA(KLO)+B*YA(KHI)+ 
c      &           ((A**3-A)*Y2A(KLO)+(B**3-B)*Y2A(KHI))*(H**2)/6.
c      RETURN
c      END
c
c
c      subroutine moving (nobs,inum,passnum,eight,gfcnt,dndk,

```

```

>           itercnt,ifirstcnt,isecnt,iendcnt,
>           13cnt,14cnt,15cnt,16cnt,17cnt,18cnt,
>           1bigcnt,1switch,1lowcnt)
integer winlen,incwen,nobs,minm,
>           wwinlen2,iincwen2,iincwen1,var,maxm,
>           gftype,passnum,eight,gfcnt,subwinlen,strnobs,
>           ggftype,wwinlen1,wwinlen2a,wwinlen2b
real data(400,27),movdata(400,27),minval,maxval,
>           varmax,strdata(400,27),intpdata(400,27),mincc,
>           x(100),y(100),y2(100),
>           sdata(400,27)
character*10 dndk
common data(400,27)
common /move/ movdata(400,27),wwinlen2,iincwen2,var,ggftype,
>           varmax,mincc,iincwen1,wwinlen1,wwinlen2a,
>           wwinlen2b
common /intb/ intpdata(400,27)

c----- subroutine description
c
c subroutine moving creates the cubic spline fit of each pass with
c a variance above the user defined limit. this cubic spline will
c match the original pass to within the user defined correlation
c coefficient. the cubic spline is the time domain representation
c of the non-lithospheric components in the pass. the following
c source was used as a reference for the statistical calculations:
c
c           Davis, Statistics and Data Analysis in
c           Geology, 2nd ed., 1986 pp. 41
c-----loops that sum x, x**2
c
strnobs=nobs
xsum=0.0
xsumsqr=0.0
xmin=data(1,var)
xmax=xmin
do 10 j=1,nobs
  xsum=xsum+data(j,var)
  xsumsqr=xsumsqr+(data(j,var))**2
  xmin=min(xmin,data(j,var))
  xmax=max(xmax,data(j,var))
10  continue
nobss=float(nobs)
c-----find corrected sum of squares and mean
c
  xcsumsqr=xsumsqr-((xsum**2)/nobss)
  xmean=xsum/nobss
c-----find variance, standard deviation
c
  xvar=xcsumsqr/(nobss-1.0)
  xstdev=sqrt(xvar)
c-----write out this mess for individual pass
c
  write (25,9992) passnum,xvar,xstdev,xmin,xmean,xmax
9992 format (16,5f14.5)
c----- if the variance of the pass is below the user
c           defined limit then race on back to main program
c
  if (xvar .le. varmax) then
    eight=7777
    return
  endif
  gftype=ggftype
  gfcnt=gfcnt+1
  do 15 i=1,nobs
    do 15 j=1,27
      strdata(i,j)=data(i,j)
15  continue
  subwinlen=0
c----- use a moving average fit
17  if (gftype .eq. 1) then
    itercnt=itercnt+1
    winlen=wwinlen1
    incwen=iincwen1
    inum=1
    if (subwinlen .gt. 0) then
      if (incwen .gt. 1) then
        incwen=incwen-subwinlen
        go to 25
      elseif (incwen .lt. winlen) then
        winlen=winlen-subwinlen
        if (winlen .lt. 2) stop 1110
      endif
      continue
    endif
    xdivide=real(nobs)/real(incwen+winlen-1)
    xp5=(real(int(xdivide)))+0.5
    if (xdivide .lt. xp5) idivide=int(xdivide)
    if (xdivide .ge. xp5) idivide=int(xdivide)+1

```

```

xwinlen=real(nobs)/real(idivide)
iwinadd=int((xwinlen-(real(int(xwinlen)))*real(idivide)))
winlen=int(xwinlen)-incwen
istrwinlen=winlen
iadd=0
if (iwinadd .gt. 0 .and. iadd .lt. iwinadd) then
  iadd=iadd+1
  winlen=winlen+1
endif
i1=(winlen-1)/2
i3-i1
i7=0
if (i1 .gt. nobs) then
  i1=nobs/2
  i7=1
endif
avgdat=0.0
do j=1,i1
  avgdat=data(j,var)+avgdat
enddo
do 20 j=1,27
  movdata(inum,j)=data(i1,j)
20  continue

movdata(inum,var)=avgdat/(real(i1))
if (i7 .eq. 1) go to 100
30  continue
winlen=istrwinlen
if (iwinadd .gt. 0 .and. iadd .lt. iwinadd) then
  iadd=iadd+1
  winlen=winlen+1
endif
i2=i3+incwen
i3=i2+winlen-1
i4=i2+((i3-i2)/2)
if (i3 .gt. nobs-i1+1) go to 100
avgdat=0.0
inum=inum+1
do 50 j=i2,i3
  avgdat=avgdat+data(j,var)
50  continue
do 70 j=1,27
  movdata(inum,j)=data(i4,j)
70  continue
movdata(inum,var)=avgdat/(i3-i2+1)

go to 30
100  continue

inum=inum+1
avgdat=0.0
do j=(nobs-i1+1),nobs
  avgdat=avgdat+data(j,var)
enddo
150  do 170 j=1,27
    movdata(inum,j)=data(nobs,j)
170  continue
movdata(inum,var)=avgdat/(real(i1))
c----- or use the minimum and maximum values
c----- within the window length
c
  elseif (gftype .eq. 2) then
    itercnt=itercnt+1
    winlen=wwinlen2
    incwen=iincwen2
    winlena=wwinlen2a
    winlenb=wwinlen2b
    if (winlena.gt.nobs .or. winlenb.gt.nobs .or.
>      incwen.gt.nobs .or. (winlena+1).ge.(nobs-winlenb)) then
      do i=1,27
        movdata(1,i)=data(1,i)
        movdata(2,i)=data(nobs,i)
      enddo
      avgdat=0.0
      do i=1,nobs/2
        avgdat=data(i,var)+avgdat
      enddo
      avgdat=avgdat/real(nobs/2)
      movdata(1,var)=avgdat
      avgdat=0.0
      do i=(nobs/2)+1,nobs
        avgdat=data(i,var)+avgdat
      enddo
      avgdat=avgdat/real(nobs-(nobs/2))
      movdata(2,var)=avgdat
      iendcnt=iendcnt+1
      inum=2
      go to 700

```

```

        endif
        avgdat=0.0
        do 500 i=1,winlena
500      avgdat=data(i,var)+avgdat
              avgdat=avgdat/real(winlena)
              do 510 i=1,27
510      movdata(1,i)=data(1,i)
              movdata(1,var)=avgdat
              i1=winlena+1
              i2=nobs-winlenb
              i3=0
              i4=nobs-winlenb+1
              i5=nobs
              i6=nobs
              maxval=-1.0e10
              minval=1.0e10
              do 520 m=i1,i2
                  minval=min(minval,data(m,var))
                  if (minval .eq. data(m,var)) minm=m
                  maxval=max(maxval,data(m,var))
                  if (maxval .eq. data(m,var)) maxm=m
520      continue
                  ilow=minm-((winlen-1)/2)
                  ihi=minm+((winlen-1)/2)
                  if (ilow .lt. 1) ilow=1
                  if (ihi .gt. nobs) ihi=nobs
                  avgdatmin=0.0
                  do 530 i=ilow,ihi
                      avgdatmin=avgdatmin+data(i,var)
                      avgdatmin=avgdatmin/real(ihi-ilow+1)
                      ilow=maxm-((winlen-1)/2)
                      ihi=maxm+((winlen-1)/2)
                      if (ilow .lt. 1) ilow=1
                      if (ihi .gt. nobs) ihi=nobs
                      avgdatmax=0.0
                      do 540 i=ilow,ihi
                          avgdatmax=avgdatmax+data(i,var)
                          avgdatmax=avgdatmax/real(ihi-ilow+1)
                          if (minm .lt. maxm) then
                            do 570 j=1,27
                                movdata(2+i3,j)=data(minm,j)
                                movdata(3+i3,j)=data(maxm,j)
                                movdata(2+i3,var)=avgdatmin
                                movdata(3+i3,var)=avgdatmax
570      continue
                            elseif (minm .gt. maxm) then
                            do 590 j=1,27
                                movdata(2+i3,j)=data(maxm,j)
                                movdata(3+i3,j)=data(minm,j)
                                movdata(2+i3,var)=avgdatmax
                                movdata(3+i3,var)=avgdatmin
590      continue
                            endif
                            avgdat=0.0
                            do 594 i=14,15
594      avgdat=data(i,var)+avgdat
                            avgdat=avgdat/real(i5-i4+1)
                            do 596 i=1,27
596      movdata(4+i3,1)=data(i6,1)
                            movdata(4+i3,var)=avgdat
                            inum=4+i3
                            if (dndk .eq. 'dusk') then
                              if (movdata(2+i3,1) .le.
>                                (movdata(1+i3,1)+(real(incwen)*0.33))) then
                                ifirstcnt=ifirstcnt+1
                                do 600 j=2,3
                                    do 600 i=1,27
                                      movdata(j+i3,1)=movdata(j+1+i3,1)
                                      inum=inum-1
                                    endif
                                    if (movdata(inum-1+i3,1) .ge.
>                                      (movdata(inum+i3,1)-(real(incwen)*0.33))) then
                                      iseccnt=iseccnt+1
                                      do 610 i=1,27
                                        movdata(inum-1+i3,1)=movdata(inum+i3,1)
                                        inum=inum-1
                                      endif
                                      elseif (dndk .eq. 'dawn') then
                                        if (movdata(2+i3,1) .ge.
>                                          (movdata(1+i3,1)-(real(incwen)*0.33))) then
                                          ifirstcnt=ifirstcnt+1
                                          do 620 j=2,3
                                            do 620 i=1,27
                                              movdata(j+i3,1)=movdata(j+1+i3,1)
                                              inum=inum-1
                                            endif
                                            if (movdata(inum-1+i3,1) .le.
>                                              (movdata(inum+i3,1)+(real(incwen)*0.33))) then
                                                iseccnt=iseccnt+1

```

```

630      do 630 i=1,27
           movdata(inum-1+i3,1)=movdata(inum+i3,1)
           inum=inum-1
      endif
      endif
      endif
c
700  continue
  if (dndk .eq. 'dusk') then
    do 401 i=1,inum
      x(i)=movdata(i,1)
      y(i)=movdata(i,var)
  401  continue
  elseif (dndk .eq. 'dawn') then
    do 404 i=1,inum
      ii=inum-i+1
      x(i)=movdata(ii,1)
      y(i)=movdata(ii,var)
  404  continue
  endif
  oneslope=(y(2)-y(1))/(x(2)-x(1))
  twoslope=(y(inum)-y(inum-1))/(x(inum)-x(inum-1))
  call spline (x,y,inum,oneslope,twoslope,y2)
  do 402 i=1,nobs
    ii=nobs-i+1
    xint=data(i,1)
    if (dndk .eq. 'dawn') xint=data(ii,1)
    call splint (x,y,y2,inum,xint,yint)
    do 403 j=1,27
      intpdata(i,j)=data(i,j)
      if (dndk .eq. 'dawn') intpdata(i,j)=data(ii,j)
  403  continue
  intpdata(i,var)=yint
  402  continue
  if (dndk .eq. 'dawn') then
    do 405 i=1,nobs
      ii=nobs-i+1
      do 405 j=1,27
        sdata(i,j)=intpdata(ii,j)
  405  continue
  do 406 i=1,nobs
    do 406 j=1,27
      intpdata(i,j)=sdata(i,j)
  406  continue
  endif
c----- calculate the correlation coefficient between
c----- the original data and the cubic spline
c----- loops that sum x, x**2, y, y**2 and xy
  if (nobs .ne. strnobs) stop 0002
  nobss=real(nobs)
  xsum=0.0
  xsumsqr=0.0
  ysum=0.0
  ysumsqr=0.0
  sumxy=0.0
  do 440 j=1,nobs
    xsum=xsum+strdata(j,var)
    xsumsqr=xsumsqr+(strdata(j,var))**2
    ysum=ysum+intpdata(j,var)
    ysumsqr=ysumsqr+(intpdata(j,var))**2
    sumxy=sumxy+(strdata(j,var)*intpdata(j,var))
  440 continue
c-----find corrected sum of products, covariance
c----- and corrected sum of squares (x) (y)
c
  sumprod=sumxy-((xsum*ysum)/nobss)
  covarxy=sumprod/(nobss-1.0)
  xcsumsqr=xsumsqr-((xsum**2)/nobss)
  ycsumsqr=ysumsqr-((ysum**2)/nobss)
c-----find variance, standard deviation for x and y
c
  xvar=xcsumsqr/(nobss-1.0)
  yvar=ycsumsqr/(nobss-1.0)
  xstdev=sqrt(xvar)
  ystdev=sqrt(yvar)
c-----find correlation coefficient by Davis method
  corrDxy=covarxy/(xstdev*ystdev)
c----- if the fit between cubic spline and original data
c----- is below the minimum acceptable user defined
c----- correlation coefficient limit, then shorten the
c----- windows by a length equivalent to subwinlen. then
c----- rerun the entire subroutine from statement 17
c
  if (corrDxy .lt. mincc .and. gftype .eq. 2) then
    write (*,*) passnum,' pass below cc limit',corrDxy
    gftype=1

```



```

IF(ABS(SL1).GT.(3.0*XSL).OR.ABS(SL1).GT.(ABS(3.0*S2))) IC(I)=0
IF(IC(I).EQ.0) THEN
  I=I+1
  GO TO 15
ENDIF
C
C*****ARE THE MID POINTS SPIKES?
C
DO 20 J=I,NPTS-2
  SL2=(DATA(J+1,var)-DATA(J+2,var))
  IF(SL1.GT.UPPER.AND.SL2.LT.LOWER) IC(J+1)=0
  IF(SL1.LT.LOWER.AND.SL2.GT.UPPER) IC(J+1)=0
  SL1=SL2
20 CONTINUE
C
C*****IS THE LAST POINT A SPIKE?
C
DO 25 K=NPTS-2,1,-1
  IF(IC(K).EQ.0) THEN
    K=K-1
    GO TO 25
  ENDIF
25 CONTINUE
C
  SL1=ABS(DATA(K,var)-DATA(NPTS-1,var))
  SL2=ABS(DATA(NPTS-1,var)-DATA(NPTS,var))
  SL3=ABS(DATA(K,var)-DATA(NPTS,var))
  IF(IC(NPTS-1).EQ.0) THEN
    IF(SL1.GT.(3.0*SL2)) IC(NPTS)=0
    IF(SL3.GT.(3.0*UPPER)) IC(NPTS)=0
  ENDIF
  IF(IC(NPTS-1).EQ.1) THEN
    IF(SL2.GT.(3.0*SL1)) IC(NPTS)=0
  ENDIF
C
  NOBS=0
DO 30 I=1,NPTS
  IF(IC(I).EQ.1) NOBS=NOBS+1
30 CONTINUE
C
  WRITE(6,*) IDATA(1,1), NOBS
C
  outnum=0
DO 35 I=1,NPTS
  IF(IC(I).EQ.1) THEN
    outnum=outnum+1
    do 32 m=1,27
      desdata(outnum,m)=data(i,m)
32    continue
  ENDIF
35 CONTINUE
C
  return
END
C
C
C
subroutine track (nf,innum,noc,nocgf)
common /trax/ x(400),y(400)
C----- subroutine description
C      this subroutine calculates the lat lon coordinates of each point
C      to be plotted in tplot for a map view of the footprint of the pass
C
RADFAC=0.017453293
nop=innum
if (nf .eq. 26) nocgf=nocgf+1
if (nf .eq. 27) noc=noc+1
DO 200 J=1,NOP
  x(j)=90.0-x(j)
  if(y(j).lt.0.) y(j)=y(j)+360.
  X(J)=X(J)*RADFAC
  Y(J)=Y(J)*RADFAC
200 CONTINUE
if (nf .eq. 26) WRITE (26) NOCgf,NOP,(X(J),Y(J),J=1,NOP)
if (nf .eq. 27) WRITE (27) NOC,NOP,(X(J),Y(J),J=1,NOP)
C
  return
end
C
C
C
C
subroutine sgrfit (innum,x,ifitvar)
real core(400),xmag(400),intpdata(400,27)
common /intb/ intpdata(400,27)
C----- subroutine description
C      sgrfit fits the core field values to the observed data
C      in a least squares manner. that is, the subroutine finds
C      a value of x that is multiplied by all core field values

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c      in a pass so that the core field model matches the
c      observed values closer.
c
c      x=0.0
c      cmean=0.0
c      fmean=0.0
c      do i=1,innum
c          core(i)=intpdata(i,16)
c          cmean=cmean+core(i)
c          xmag(i)=intpdata(i,ifitvar)
c          fmean=fmean+xmag(i)
c      enddo
c
c      cmean=cmean/real(innum)
c      fmean=fmean/real(innum)
c
c      do i=1,innum
c          xmag(i)=xmag(i)-fmean
c          core(i)=core(i)-cmean
c      enddo
c
c      ctc=0.0
c      do 600 i=1,innum
c          ctc=(core(i)*core(i))+ctc
c
c      ctcinv=1.0/ctc
c
c      ctf=0.0
c      do 700 i=1,innum
c          ctf=(core(i)*xmag(i))+ctf
c
c      x=ctcinv*ctf
c
c      do 800 i=1,innum
c          intpdata(i,ifitvar)=xmag(i)-(core(i)*x)
c
c 999 continue
c      return
c      end

```



```

program movetrunc
integer xrow,xcol,zero,eight,xpassno,ypassno,ycol,
>      x3row,x3col,x3pass,y3row,y3col,y3pass,yrow,
>      strcnt,nobs,dndk,tcount,paircnt,nowant(4000),nocnt,
>      paircnt1,jstop,minobs,passrem,totpass,global,
>      outto,nopass,type,noc
real xmean,ymean,x3data(400,3),y3data(400,3),y3mean,
>      x1data(400),y1data(400),xadata(400,4),ybdata(400,4),
>      x3mean,xmean,ybmean,x(400),y(400)
character*80 filename
common /tpplot/ x(400),y(400)
common /nope/ nowant(4000),nocnt
common /trunstat/ xadata(400,4),ybdata(400,4)
common /rowcol/ x3row,y3row,xrow,yrow,x3col,y3col,xcol,ycol,
>      x3mean,y3mean,xmean,ymean,x3pass,y3pass,
>      xpassno,ypassno
common x3data(400,3),x1data(400),y3data(400,3),y1data(400)

c----- program description
c
c      this program truncates, in the time domain, two adjacent passes
c      to the same length. this program should be used only after the
c      passes have been reordered by program reorder. truncation is
c      accurate in the time domain rather than in the frequency domain.
c      this program is used before program fourier which is used to
c      extract the similar wavelengths of adjacent passes.
c
c      program date: 16 apr 91
c
      write (*,*) 'INPUT FILE X OF LAT-LONG-RAD DATA'
      read (*,9990) filename
9990 format(a80)
      open (10, file=filename,status='old',form='unformatted')
      write (*,*) 'INPUT FILE X OF MAGNETIC VARIABLES'
      read (*,9990) filename
      open (11, file=filename,status='old',form='unformatted')

c      write (*,*) '0 IF THE DATA IS GLOBAL OR POLAR'
      write (*,*) '1 IF THE DATA DOES NOT INCLUDE ALL LONGITUDES'
      read (*,*) global
      if (global.eq.0) then
         write (*,*) 'NOTE: FILE Y WILL HAVE THE FIRST PASS MOVED'
         write (*,*) 'TO THE BOTTOM OF THE FILE'
         write (*,*) ''
      elseif (global.eq.1) then
         write (*,*) 'NOTE: OUTPUT FILE X WILL NOT INCLUDE THE LAST PASS'
         write (*,*) 'FILE Y WILL NOT INCLUDE THE FIRST PASS'
         write (*,*) ''
      endif

c      write (*,*) 'OUTPUT FILE X OF TRUNCATED LAT-LONG-RAD DATA'
      read (*,9990) filename
      open (20, file=filename,form='unformatted')
      write (*,*) 'OUTPUT FILE X OF TRUNCATED MAGNETIC VARIABLES'
      read (*,9990) filename
      open (21, file=filename,form='unformatted')
      write (*,*) 'OUTPUT FILE Y OF TRUNCATED LAT-LONG-RAD DATA'
      read (*,9990) filename
      open (22, file=filename,form='unformatted')
      write (*,*) 'OUTPUT FILE Y OF TRUNCATED MAGNETIC VARIABLES'
      read (*,9990) filename
      open (23, file=filename,form='unformatted')
      write (*,*) 'OUTPUT FILE OF TRACK PROFILES TO BE RUN IN TPLOT'
      read (*,9990) filename
      open (24, file=filename,form='unformatted')
      write (*,*) 'OUTPUT FILE OF STATISTICS'
      read (*,9990) filename
      open (25, file=filename,form='formatted')

c      write (*,*) '0 IF THESE ARE DUSK DATA SETS'
      write (*,*) '1 IF THESE ARE DAWN DATA SETS'
      read (*,*) dndk
      write (*,*) '0 IF ALL PASSES ARE WANTED'
      write (*,*) '1 IF SOME PASSES SHOULD BE REMOVED'
      read (*,*) nocnt
      if (nocnt.eq.1) then
         write (*,*) 'INPUT FILE OF PASS NUMBERS NOT WANTED'
         read (*,9990) filename
         open (26, file=filename,status='old',form='formatted')
         do 10 i=1,4000
            read (26,*,end=15) nowant(i)
10      continue
15      continue
         nocnt=i-1
      endif
      write (*,*) 'MINIMUM NUMBER OF OBSERVATIONS FOR EACH PASS'
      read (*,*) minobs
      write (*,*) 'TYPE OF GAP FINDER (2)'
      write (*,*) '1 FOR ONLY FINDING GAPS'
      write (*,*) '2 FOR USING THE MINIMUM OBSERVATIONS'

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        read (*,*) type
c
        write (*,*) '-----'
        write (*,*) 'running through dataset to find passes',
        >           'that do not overlap'
c
c----- subroutine findgap locates passes that do not
c           have overlapping segments and removes the
c           shorter of the two passes. the subroutine
c           continues reading and rereading the dataset
c           until all non-overlapping segments are removed
c
        call findgap (global,dndk,minobs,type)
        write (*,*) 'done with run through'
        write (*,*) '-----'
c
        write (25,*) 'XPASS YPASS CCD      CCY      XVAR      YVAR  ',
        >           'COVARXY  XSTDEV  YSTDEV'
        write (25,*) '          XMEAN  YMEAN      XSLOPE  YSLOPE',
        >           XINTCPT  YINTCPT'
        paircnt=0
        paircnt1=0
        tcount=0
        strcnt=0
        jstop=0
        passrem=0
        totpass=0
c
        30  continue
        read (10,end=90) y3row,y3col,zero,y3mean,y3pass,eight
        do 35 i=1,y3row
           read (10) (y3data(i,ii),ii=1,y3col)
        35  continue
        read (11) yrow,ycol,zero,ymean,ypassno,eight
        do 45 i=1,yrow
           read (11) yldata(i)
        45  continue
        totpass=totpass+1
        if (yrow .lt. minobs .or. y3row .lt. minobs) then
           write (*,*) y3pass,ypassno,' PASS REMOVED: ROWS=',y3row,yrow
           passrem=passrem+1
           go to 30
        endif
        if (nocnt .eq. 0) go to 55
        do 50 i=1,nocnt
           if (ypassno .eq. nowant(i)) then
              write (*,*) ypassno,y3pass,' PASS REMOVED'
              passrem=passrem+1
              go to 30
           endif
        50  continue
        55  continue
        go to 95
c----- this little jump around is used
c           to get the last and first passes
c

        of global datasets truncated
90   jstop=1
        if (global .eq. 1) go to 999
c
95   continue
        strcnt=strcnt+1
c----- offset the data file in subroutine
c           movtrun
        if (strcnt .eq. 1) call movtrun (-1,outto,jstop)
        if (strcnt .gt. 1) call movtrun (0,outto,jstop)
        if (outto) 30,100,100
c----- truncate the passes to the same length
100  continue
        nopass=0
        call truncate (xrow,yrow,dndk,nobs,paircnt1,nopass,
        >           xpassno,ypassno)
        if (nopass .gt. 0) then
c----- if this happens, then subroutine
c

        findgap didn't work just right
        write (*,*) 'OH MAN HAVE YOU GOT TROUBLE NOW'

        stop
        endif
c----- do a little statistical nonsense
c
        call statistics (nobs,xpassno,ypassno,xamean,ybmean)
c

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c-----write out the truncated lengths of passes
c
c      write (20) nobs,x3col,zero,xamean,xpassno,eight
c      write (21) nobs,xcol,zero,xamean,xpassno,eight
c      write (22) nobs,y3col,zero,ybmean,ypassno,eight
c      write (23) nobs,ycol,zero,ybmean,ypassno,eight
c      do 200 j=1,nobs
c          write (20) xadata(j,1),(xadata(j,1),i=3,4)
c          write (21) xadata(j,2)
c          write (22) ybdata(j,1),(ybdata(j,1),i=3,4)
c          write (23) ybdata(j,2)
c 200  continue
c
c      call track (nobs,noc)
c      WRITE (24) NOC,NObs, (X(J),Y(J),J=1,NObs)
c
c      if (paircntl .gt. 0) tcount=tcount+1
c      paircnt=paircnt+paircntl
c      if (jstop .eq. 1) go to 999
c
c      call movtrun (1,outto,jstop)
c      if (outto) 30,999,999
c
c
c 999  continue
c      if (global .eq. 1) strcnt=strcnt-1
c      write (*,*) 'corrected',paircnt,' pairs of latitudes in'
c      write (*,*) tcount,' passes to beginning lengths'
c      write (*,*) 'total passes read - ',totpass
c      write (*,*) 'removed',passrem,' passes from processing'
c      write (*,*) 'total passes written - ',strcnt
c      close (10)
c      close (11)
c      close (20)
c      close (21)
c      close (22)
c      close (23)
c      close (25)
c      stop
c      end
c
c
c      subroutine truncate (xrow,yrow,dndk,minrow,stocount,nopass,
c      >           xpassno,ypassno)
c      integer xrow,yrow,stocount,rowi1,rowinc,minrow,nocnt,
c      >           dndk,nopass,minxyrow,nowant(4000),xpassno,ypassno
c      real xdata(400,4),ydata(400,4),
c      >           x3data(400,3),x1data(400),y3data(400,3),y1data(400),
c      >           adata,bdata,diffab,abss,xadata(400,4),ybdata(400,4)
c      common /trunstat/ xadata(400,4),ybdata(400,4)
c      common /nope/ nowant(4000),nocnt
c      common x3data(400,3),x1data(400),y3data(400,3),y1data(400)
c
c----- subroutine description
c
c      this subroutine truncates two sets of values to the same length.
c      truncation is based on the independent variable which is the
c      latitude of each point along a pass. these values must be
c      interpolated to every 0.33 degrees.
c
c      do 70 j=1,xrow
c          xdata(j,1)=x3data(j,1)
c          xdata(j,2)=x1data(j)
c          xdata(j,3)=x3data(j,2)
c          xdata(j,4)=x3data(j,3)
c 70  continue
c      do 75 j=1,yrow
c          ydata(j,1)=y3data(j,1)
c          ydata(j,2)=y1data(j)
c          ydata(j,3)=y3data(j,2)
c          ydata(j,4)=y3data(j,3)
c 75  continue
c
c 80  continue
c      stocount=0
c      jj=1
c      rowi1=xrow
c      rowinc=yrow
c
c-----loops from 90 to 200 increment through the
c      two input passes and truncate the lengths
c      to the same length
c
c 90  continue
c      adata=xdata(jj,1)
c      bdata=ydata(jj,1)
c      diffab=adata-bdata
c      abss=abs(diffab)
c      if (rowi1 .eq. 0 .or. rowinc .eq. 0) then
c          minxyrow=min(xrow,yrow)
c          if (minxyrow .eq. xrow) then

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nopass=xpassno
nowant(nocnt+1)=xpassno
write (*,*) 'xrows (ii) =',rowii,' yrows (inc) =',rowinc
write (*,*) 'rerunning to remove x pass number =',xpassno
write (*,*) 'xrow =',xrow,' yrow =',yrow
return
elseif (minxyrow .eq. yrow) then
  nopass=ypassno
  nowant(nocnt+1)=ypassno
  write (*,*) 'xrows (ii) =',rowii,' yrows (inc) =',rowinc
  write (*,*) 'rerunning to remove y pass number =',ypassno
  write (*,*) 'xrow =',xrow,' yrow =',yrow
return
endif
endif
minrow=min(rowii,rowinc)
c  write (*,*) rowii,rowinc,minrow
c  write (*,*) adata,bdata,abss
c-----if pass a (ii) matches pass b (inc) at
c           beginning length then write to xdata and
c           ydata and race to main program
c
  if (abss .lt. 0.33) then
    do 110 ll=1,minrow
      do 110 kk=1,4
        xadata(ll,kk)=xdata(ll,kk)
        ybdata(ll,kk)=ydata(ll,kk)
      write (*,*) xdata(ll),ydata(ll)
  110  continue
  return
endif
c-----if pass a no matcha the b data then find new
c           a or b depending on whether or not ascending
c           or descending order of independent variable
c
  if (abss .ge. 0.33) then
    stocount=stocount+1
c-----if this is a dusk pass then will count from
c           -90.0 lat degrees toward the equator
  if (dndk .eq. 0) then
    if (xdata(jj,1) .gt. ydata(jj,1)) then
      rowinc=rowinc-1
      do 130 mm=1,rowinc
        do 130 kk=1,4
          ydata(mm,kk)=ydata(mm+1,kk)
        write (*,*) ydata(mm,kk)
  130  continue
    elseif (xdata(jj,1) .lt. ydata(jj,1)) then
      rowii=rowii-1
      do 150 nn=1, rowii
        do 150 kk=1,4
          xdata(nn,kk)=xdata(nn+1,kk)
        continue
  150  endif
c-----if this is a dawn pass then will count from
c           the equator toward the south pole
c           that is decreasing independent variable
    elseif (dndk .eq. 1) then
      if (xdata(jj,1) .lt. ydata(jj,1)) then
        rowinc=rowinc-1
        do 160 mm=1, rowinc
          do 160 kk=1,4
            ydata(mm,kk)=ydata(mm+1,kk)
          write (*,*) ydata(mm,kk)
  160  continue
        elseif (xdata(jj,1) .gt. ydata(jj,1)) then
          rowii=rowii-1
          do 170 nn=1, rowii
            do 170 kk=1,4
              xdata(nn,kk)=xdata(nn+1,kk)
            continue
  170  endif
      endif
    endif
  go to 90
c
c
c
c
  subroutine statistics (minrow,xpassno,ypassno,xamean,ybmean)
  integer minrow,nobs,xpassno,ypassno
  real xadata(400,4),ybdata(400,4),nobss
  common /trunstat/ xadata(400,4),ybdata(400,4)
c
c           the statistical calculations using two
c           references:
c           1) Davis, Statistics and Data Analysis in
c              Geology, 2nd ed., 1986 pp. 41
c           2) Young, Statistical Treatment of Experi-

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c                                mental Data, 1962, McGraw Hill, 115-132
c
c-----loops that sum x, x**2, y, y**2 and xy
c-----and calculate new truncated means
c
nobs=minrow
nobss=float(nobs)
xsum=0.0
xsumsqr=0.0
ysum=0.0
ysumsqr=0.0
sumxy=0.0
do 240 j=1,nobs
    xsum=xsum+xadata(j,2)
    xsumsqr=xsumsqr+(xadata(j,2))**2
    ysum=ysum+ybdata(j,2)
    ysumsqr=ysumsqr+(ybdata(j,2))**2
    sumxy=sumxy+(xadata(j,2)*ybdata(j,2))
240  continue
c     write (*,*) xsum,ysum,xsumsqr,ysumsqr,sumxy
c-----find corrected sum of products, covariance
c-----and corrected sum of squares (x) (y)
c
xamean=xsum/nobss
ybmean=ysum/nobss
sumprod=sumxy-((xsum*ysum)/nobss)
covarxy=sumprod/(nobss-1.0)
xcsumsqr=xsumsqr-((xsum**2)/nobss)
ycsumsqr=ysumsqr-((ysum**2)/nobss)
c
c-----find variance, standard deviation for x and y
c
xvar=xcsumsqr/(nobss-1.0)
yvar=ycsumsqr/(nobss-1.0)
xstdev=sqrt(xvar)
ystdev=sqrt(yvar)
c-----find correlation coefficient by Davis method
corrDxy=covarxy/(xstdev*ystdev)
c-----find slopes, intercepts and correlation
c-----coefficient by Young method
xslope=((nobss*sumxy)-(xsum*ysum))/((nobss*xsumsqr)-xsum**2)
yslope=((nobss*sumxy)-(xsum*ysum))/((nobss*ysumsqr)-ysum**2)
xintcpt=((ysum*xsumsqr)-(sumxy*xsum))/((nobss*xsumsqr)-xsum**2)
yintcpt=((xsum*ysumsqr)-(sumxy*ysum))/((nobss*ysumsqr)-ysum**2)
corrXxy=sqrt(xslope*yslope)
c-----write out this mess for individual pass and
c-----overlapping lengths of passes
c
c     write (25,9992)xpassno,ypassno,xvar,yvar,xstdev,ystdev,
c     >           xamean,ybmean
9992 format ('FOR OVERLAPPING LENGTHS  X',15,' Y',15,/,
  >           'X VARIANCE-',f9.3,' Y VARIANCE-',f9.3,' X STDEV-',
  >           f9.3,' Y STDEV-',f9.3,' XMEAN-',f9.3,' YMEAN-',f9.3)
c     write (25,9993) covarxy,corrDxy
9993 format ('COVARIANCE XY-',f9.3,' Davis CORRELATION COEF-',f9.3)
c     write (25,9994) xslope,xintcpt,yslope,yintcpt,corrXxy
9994 format ('X SLOPE-',f9.3,' X INTERCEPT-',f9.3,' Y SLOPE-',
  >           f9.3,' Y INTERCEPT-',f9.3,' Young CORRELATION COEF-',
  >           f9.3,/)
c     write (25,9995) xpassno,ypassno,corrDxy,corrXxy,xvar,yvar,
c     >           covarxy,xstdev,ystdev
9995 format (215,7(f10.4))
write (25,9996) xamean,ybmean,xslope,yslope,xintcpt,yintcpt
9996 format (10x,6(f10.4))
return
end
c
c
c     subroutine movtrun (into,outto,jstop)
integer into,outto,sy3row,syrow,sy3col,sycol,
  >           sy3pass,ypassno,jstop,
  >           y3row,yrow,y3col,ycol,y3pass,ypassno,
  >           x3row,xrow,x3col,xcol,x3pass,xpassno,
  >           sx3row,sxrow,sx3col,sxcol,sx3pass,sxpassno
real x3data(400,3),xidata(400),y3data(400,3),yldata(400),
  >           sy3mean,symean,savey3(400,3),savey1(400),y3mean,
  >           ymean,x3mean,xmean,storex3(400,3),storex1(400),
  >           sx3mean,sxmean
common x3data(400,3),xidata(400),y3data(400,3),yldata(400)
common /rowcol/ x3row,y3row,xrow,yrow,y3col,y3col,xcol,ycol,
  >           x3mean,y3mean,xmean,ymean,x3pass,y3pass,
  >           xpassno,ypassno
c
c-----subroutine description
c     this subroutine stores one pass so that the offset
c     will occur.
c     if (jstop) 10,10,350
10  if (into) 40,85,290

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```

c
40  continue
    do 50 i=1,y3row
        do 55 ii=1,y3col
            savey3(i,ii)=y3data(i,ii)
55  continue
    savey1(i)=y1data(i)
50  continue
    sy3row=y3row
    syrow=yrow
    sy3col=y3col
    sycol=ycol
    sy3mean=y3mean
    symean=ymean
    sy3pass=y3pass
    sypassno=ypassno
c
    do 70 i=1,y3row
        do 75 ii=1,y3col
            x3data(i,ii)=y3data(i,ii)
75  continue
    x1data(i)=y1data(i)
70  continue
    x3row=y3row
    xrow=yrow
    x3col=y3col
    xcol=ycol
    x3mean=y3mean
    xmean=ymean
    x3pass=y3pass
    xpassno=ypassno
c
    outto = -1
    return
c
c
85  continue
    do 90 i=1,y3row
        do 95 ii=1,y3col
            storex3(i,ii)=y3data(i,ii)
95  continue
    storex1(i)=y1data(i)
90  continue
    sx3row=y3row
    sxrow=yrow
    sx3col=y3col
    sxcol=ycol
    sx3mean=y3mean
    sxmean=ymean
    sx3pass=y3pass
    sxpassno=ypassno
c
    if (xrow.ne.x3row .or. xpassno.ne.x3pass .or.
>     yrow.ne.y3row .or. ypassno.ne.y3pass) then
        write (*,*) 'WACKO, TRA-LA-LA, JOLLY-GOOD, NO MATCH BETWEEN'
        write (*,*) 'ROWS OR PASSNOS X= ',xrow,x3row,xpassno,x3pass
        write (*,*) 'Y= ',yrow,y3row,ypassno,y3pass
        stop
    endif
c
    outto = 0
    return
c
c
290  continue
    x3row=sx3row
    xrow=sxrow
    x3col=sx3col
    xcol=sxcol
    x3mean=sx3mean
    xmean=sxmean
    x3pass=sx3pass
    xpassno=sxpassno
    do 300 i=1,x3row
        do 305 ii=1,x3col
            x3data(i,ii)=storex3(i,ii)
305  continue
    x1data(i)=storex1(i)
300  continue
c
    outto = -1
    return
c
c
350  continue
    do 360 i=1,sy3row
        do 365 ii=1,sy3col
            y3data(i,ii)=savey3(i,ii)
365  continue
    y1data(i)=savey1(i)

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```

360 continue
y3row=sy3row
yrow=syrow
y3col=sy3col
ycol=sycol
y3mean=sy3mean
ymean=symean
y3pass=sy3pass
ypassno=sypassno
c
  cutto = 0
  return
c
  end
c
c
c
  subroutine findgap (global,dndk,minobs,type)
  integer zero,eight,minxyrow,xrow,yrow,type,
  >      y3row,y3col,y3pass,xcnt,ycnt,strmincnt,
  >      dndk,nowant(4000),nocnt,xpassno,ypassno,
  >      minobs,totpass,global,both,nocnt2,
  >      nopass,strnocnt,allcnt
  real y3data(4000,3),y3mean,abss,alldata(4000,4)
  common /nope/ nowant(4000),nocnt
c----- subroutine description
c      findgap locates two adjacent passes that do not have
c      any common overlapping segment. if it finds two such
c      passes, then it removes the shorter of the two, continues
c      running through the remainder of the data while searching
c      for non-overlapping passes, and finally reruns through
c      the data set to assure that all non-overlapping passes
c      have been located.
c
  totpass=0
  allcnt=0
  strnocnt=nocnt
c----- read through the data only once and
c      store the pass number, first lat and
c      last lat in array alldata
30  continue
  read (10,end=60) y3row,y3col,zero,y3mean,y3pass,eight
  do 35 i=1,y3row
    read (10) (y3data(i,ii),ii=1,y3col)
35  continue
  totpass=totpass+1
  if (y3row .lt. minobs) go to 30
  if (nocnt .eq. 0) go to 55
  do 50 i=1,nocnt
    if (y3pass .eq. nowant(i)) go to 30
50  continue
55  continue
  allcnt=allcnt+1
  alldata(allcnt,1)=real(y3pass)
  alldata(allcnt,2)=real(y3row)
  alldata(allcnt,3)=y3data(1,1)
  alldata(allcnt,4)=y3data(y3row,1)
  go to 30
60  continue
c----- depending on the type of gap
c

      finder chosen, the program
c      if (type .eq. 2) go to 400      will proceed as appropriate
c
70  continue
  jstop=0
c----- xcnt and ycnt represent the two
c      adjacent passes
  xcnt=1
  ycnt=2
c----- the next two if statements check
c      if one of the two adjacent passes
c      is not wanted
  if (nocnt .eq. 0) go to 100
  do 80 i=1,nocnt
    if (int(alldata(xcnt,1)) .eq. nowant(i)) then
      do 90 jj=xcnt,allcnt-1
        do 90 jj=1,4
          alldata(jj,j)=alldata(jj+1,j)
90  continue
  allcnt=allcnt-1
  go to 70
  endif
80  continue
c
100 continue
  if (nocnt .eq. 0) go to 140

```

```

do 110 i=1,nocnt
  if (int(alldata(ycnt,1)) .eq. nowant(i)) then
    if (ycnt+1 .gt. allcnt) then
      ycnt=ycnt+1
      go to 195
    elseif (jstop .eq. 1) then
      ycnt=ycnt+1
      go to 100
    endif
    do 105 jj=ycnt,allcnt-1
      do 105 jj=1,4
        alldata(jj,j)=alldata(jj+1,j)
    105  continue
    allcnt=allcnt-1
    go to 100
  endif
110  continue
140  continue
both=0
abss=abs(alldata(xcnt,3)-alldata(ycnt,3))
if (abss .lt. 0.33) go to 190
if (abss .ge. 0.33) then
c----- truncation time!
  xrow=int(alldata(xcnt,2))
  yrow=int(alldata(ycnt,2))
  xpassno=int(alldata(xcnt,1))
  ypassno=int(alldata(ycnt,1))
  minxyrow=min(xrow,yrow)
  nopass=xpassno
  if (minxyrow .eq. yrow) nopass=ypassno
  if (xrow .eq. yrow) both=1
  nocnt2=nocnt
c-----if this is a dusk pass then will count from
c      -90.0 lat degrees toward the equator
  if (dndk .eq. 0) then
    if (alldata(xcnt,3) .gt. alldata(ycnt,3)) then
      if (alldata(xcnt,3) .gt. alldata(ycnt,4)) then
        nocnt=nocnt+1
        nowant(nocnt)=nopass
      endif
    elseif (alldata(xcnt,3) .lt. alldata(ycnt,3)) then
      if (alldata(xcnt,4) .lt. alldata(ycnt,3)) then
        nocnt=nocnt+1
        nowant(nocnt)=nopass
      endif
    endif
c-----if this is a dawn pass then will count from
c      the equator toward the south pole
c      that is decreasing independent variable
  elseif (dndk .eq. 1) then
    if (alldata(xcnt,3) .lt. alldata(ycnt,3)) then
      if (alldata(xcnt,3) .lt. alldata(ycnt,4)) then
        nocnt=nocnt+1
        nowant(nocnt)=nopass
      endif
    elseif (alldata(xcnt,3) .gt. alldata(ycnt,3)) then
      if (alldata(xcnt,4) .gt. alldata(ycnt,3)) then
        nocnt=nocnt+1
        nowant(nocnt)=nopass
      endif
    endif
    if (nocnt .gt. nocnt2 .and. both .eq. 1) then
      nocnt=nocnt+1
      nowant(nocnt)=xpassno
    endif
  endif
c
190  continue
  xcnt=ycnt
  ycnt=ycnt+1
  if (jstop .eq. 1) go to 200
195  if (ycnt .gt. allcnt) then
    if (global .eq. 1) go to 200
    ycnt=1
    jstop=1
  endif
  go to 100
c
200  continue
  if (nocnt .eq. strnocnt) go to 999
  if (strnocnt .lt. nocnt) then
    strnocnt=nocnt
    go to 70
  endif
c
400  continue
  mincnt=0
  strmincnt=mincnt

```

```

c
470  continue
jstop=0
c----- xcnt and ycnt, see notes above
      xcnt=1
      ycnt=2
      if (int(alldata(xcnt,2)) .lt. minobs) then
          do 490 jj=xcnt,alldata-1
              do 490 j=1,4
                  alldata(jj,j)=alldata(jj+1,j)
490  continue
      alldata-1
      go to 470
      endif
c
500  continue
      if (int(alldata(ycnt,2)) .lt. minobs) then
          if (ycnt+1 .gt. alldata) then
              ycnt=ycnt+1
              go to 595
          elseif (jstop .eq. 1) then
              ycnt=ycnt+1
              go to 500
          endif
          do 505 jj=ycnt,alldata-1
              do 505 j=1,4
                  alldata(jj,j)=alldata(jj+1,j)
505  continue
      alldata-1
      go to 500
      endif
510  continue
540  continue
      abss=abs(alldata(xcnt,3)-alldata(ycnt,3))
      if (abss .lt. 0.33) go to 590
      if (abss .ge. 0.33) then
          xrow=int(alldata(xcnt,2))
          yrow=int(alldata(ycnt,2))
          minxyrow=min(xrow,yrow)
          mincnt2=mincnt
c-----if this is a dusk pass then will count from
c-----      -90.0 lat degrees toward the equator
      if (dndk .eq. 0) then
          if (alldata(xcnt,3) .gt. alldata(ycnt,3)) then
              if (alldata(xcnt,3) .gt. alldata(ycnt,4)) mincnt=mincnt+1
              elseif (alldata(xcnt,3) .lt. alldata(ycnt,3)) then
                  if (alldata(xcnt,4) .lt. alldata(ycnt,3)) mincnt=mincnt+1
              endif
c-----if this is a dawn pass then will count from
c-----      the equator toward the south pole
c-----      that is decreasing independent variable
      elseif (dndk .eq. 1) then
          if (alldata(xcnt,3) .lt. alldata(ycnt,3)) then
              if (alldata(xcnt,3) .lt. alldata(ycnt,4)) mincnt=mincnt+1
              elseif (alldata(xcnt,3) .gt. alldata(ycnt,3)) then
                  if (alldata(xcnt,4) .gt. alldata(ycnt,3)) mincnt=mincnt+1
              endif
          if (mincnt .gt. mincnt2) minobs=minxyrow+1
      endif
c
590  continue
      xcnt=ycnt
      ycnt=ycnt+1
      if (jstop .eq. 1) go to 600
595  if (ycnt .gt. alldata) then
          if (global .eq. 1) go to 600
          ycnt=1
          jstop=1
          endif
          go to 500
c
600  continue
      if (mincnt .eq. strmincnt) go to 999
      if (strmincnt .lt. mincnt) then
          strmincnt=mincnt
          go to 470
      endif
c
999  continue
      write (*,*) 'total passes read = ',totpass
      if (nocnt .gt. 0) then
          write (*,*) 'will remove the following passes from processing'
          do 1010 i=1,nocnt
              write (*,*) nowant(i),i
1010  continue
      endif
      if (type .eq. 2) write (*,*) 'new minimum observation cutoff',
      >                                ' is ',minobs
      rewind (10)

```

```

c
c      return
c      end
c
c
c      subroutine track (nop,noc)
c      integer nop,noc
c      real radfac,x(400),y(400),xadata(400,4),ybdata(400,4)
c      common /tplot/ x(400),y(400)
c      common /trunstat/ xadata(400,4),ybdata(400,4)
c----- subroutine description
c      track stores the lat and long coordinates of each
c      data point along a pass. these coordinates are then
c      used to plot with a graphics package, the track footprint
c      of the satellite.
c      NOTE: the lat and long values are converted to radian values
c            because the plotting package that i work with utilizes
c            radians.
c      RADFAC=0.017453293
c      noc=noc+1
c      do 300 j=1,nop
c          x(j) = 90.0 - xadata(j,1)
c          y(j) = xadata(j,3)
c          if (y(j) .lt. 0.0) y(j) = y(j) + 360.0
c          x(j) = x(j) * radfac
c          y(j) = y(j) * radfac
c 300  continue
c
c      return
c      end

```



```

program fourier1d
character*80 filename
real xdata(4096),ydata(4096),xmean,ymean,minccin,
>   prcnt,delta,cuthi,cutlo,xlag,mincc,maxcc,short,long,
>   maxccin,cxlag,strxdata(4096)
integer xpassno,ypassno,zero,eight,file,xcol,xrow,ycol,yrow,
>   trnsf,lhb,cc,trnsb,npass,imean,cnwind,seven,
>   nwind,numfile,nxout,nyout,match,gfcnt,xnobs,ynobs
complex xcdata(4096),ycdata(4096)
common /rowcol/ xnobs,ynobs
common /fftifft/ nobs,prcnt,imean,fold
common /lhbfft/ delta,cuthi,cutlo,xlag,npass,nwind
common /ccfft/ mincc,maxcc,match,minccin,maxccin,cnwind,cxlag
common /reals/ xdata,ydata
common /comps/ xcdata,ycdata

c-----program description
c
c fourier1d is an all encompassing fourier analysis program!
c subroutines include the fft for forward and inverse situations,
c a bandpass filter which can be adjusted to perform low, high and
c bandpass filtering of wave numbers and a correlation coefficient
c filter which zeros out wavenumbers according to correlation
c coefficients. both the bandpass filter and the correlation
c coefficient filter provide the user with several windowing options
c (as well as no windowing option) to smooth wavenumbers prior
c to inverse transformation. both filters use the same subroutine
c to window in the TIME (real number data) domain. with respect to
c run time considerations: if many different datasets are submitted
c at the same time to the program, it will still calculate the same
c BANDPASS windowing function for each dataset every time it
c encounters a new dataset. since this windowing function need only
c be calculated once, it causes the program to do needless work. i
c hope to soon remedie this little time consuming "bug". big note of
c caution: the windowing function will change with each new dataset
c for the CORRELATION FILTER and therefore, leave it alone!!
c
c NOTE: ANY fourier analysis routine can be inserted
c to this program as a subroutine. maybe i'll put in
c such features as upward continuation, etc..
c
c NOTE: the only data variables absolutely necessary as INPUT are
c the number of observations of input profile, the remaining
c variables; zero,mean,pass-number and eight, are not needed.
c but, mean can be an OUTPUT if desired.
c
c updates:
c   30 Jan 91
c   this update pertained to removing calls to differing fft2d
c   subroutines so that now all calls are to the same fft2d
c   subroutine. and more importantly, now the fft2d routines
c   will handle 1 row of data so that the bandpass filter works
c   correctly. and even more importantly the zero filling option
c   now zero fills such that the data is located in the middle
c   of all those wonderful zeros. and for those of you who are
c   really into this, you can now fold out a percentage of the
c   edge of your data, smooth the folded out part to zero, fft,
c   filter, and ifft such that edge effects are minimized.
c   ohh boy!!
c
c   9 jul 92:
c   major revisions changing code from two-dimensionally based
c   ffts to one-dimensional ffts. revisions include removal of
c   subroutines transpo and store. major changes to subroutines
c   fft2d (which is now known as fft1d), dat wnd, bndpas and
c   window. now there is no longer a need for transposing the
c   arrays so that run time should be decreased.
c
c   NOTE: i removed a great deal of comments at the beginning of
c   the subroutines. all removed comments discussed the
c   two dimensional sense of the routine. i added comments
c   dealing specifically with the one dimensional changes.
c
c
c   write (*,*) '0 IF YOU HAVE A FILE OF ALL VARIABLES'
c   write (*,*) '1 IF YOU WANT TO TYPE THEM INTERACTIVELY -- ha ha'
c   read (*,*) file
c   if (file .eq. 0) then
c     write (*,9988)
9988   format ('USE THE FOLLOWING ORDER FOR INPUT FILE',
>   'IF VARIABLE DOES NOT APPLY INPUT ANY BOGUS NUMBER',
>   'numfile',
>   'lhb cc',
>   'nobs fold prcnt imean',
>   'delta short long npass',
>   'nwind xlag',
>   'mincc maxcc match minccin maxccin cnwind cxlag',
>   'isub')
c   write (*,*) 'INPUT FILE OF VARIABLES'
c   read (*,9990) filename
c   open (22, file=filename, form='formatted', status='old')
c   go to 100

```

```

        elseif (file .eq. 1) then
          go to 50
        elseif (file .ne. 0 .or. file .ne. 1) then
          write (*,*) 'HEY HEY HEY ITS BAD FILE NUMBER AND YOU GOT'
          write (*,*) 'TO MAKE A NEW CHOICE TOOOOOOO -- to the tune of'
          write (*,*) 'fat albert'
          go to 999
        endif
      c
      50  continue
      write (*,9989)
9989 format ('1 IF YOU HAVE ONLY ONE FILE TO BE FOURIERED',
      >           '2 IF YOU HAVE TWO FILES TO BE COMPARED')
      read (*,*) numfile
      c
      write (*,9991)
9991 format ('1 FOR ONLY LOW-HIGH-BAND FILTER THE DATA',
      >           '2 FOR L-H-B FILTER THEN C-C FILTER THE DATA',
      >           '3 FOR L-H-B THEN C-C THEN L-H-B FILTER THE DATA',
      >           '4 FOR C-C FILTER THEN L-H-B FILTER THE DATA',
      >           '5 FOR C-C THEN L-H-B THEN C-C FILTER THE DATA',
      >           '6 DO NOT FILTER THE DATA',
      >           '1 FOR ONLY CORRELATION COEFFICIENT FILTER THE DATA',
      >           '2 DO NOT C-C FILTER THE DATA',
      >           'choose 2 if 5 or less was chosen above',
      >           'lhb cc')
      read (*,*) lhb,cc
      c
      write (*,9992)
9992 format ('THE FOLLOWING REFERS TO FFT AND IFFT',
      >           'NUMBER OF OBSERVATIONS FOR FFT ARRAY',
      >           'AT A POWER OF 2: (256) (2 16 32 64 128 256 etc)',
      >           'PERCENT OF DATA TO BE FOLDED OUT (0.1 TO 99.9)',
      >           'PERCENT OF EACH EDGE OF INPUT ARRAY OR FOLDED',
      >           'OUT ARRAY TO BE SMOOTHED TO ZERO (0.1 TO 49.9)',
      >           '0 DO NOT ADD MEAN TO IFFT DATA',
      >           '1 ADD MEAN OF INPUT DATA TO OUTPUT IFFT DATA',
      >           'nobs fold prcnt imean')
      read (*,*) nobs,fold,prcnt,imean
      c
      if (nobs .gt. 4096) then
        write (*,8999) nobs
8999  format (1x,'SORRY',16,1x,'IS GREATER THAN 4096 THE',
      >           ' SIZE OF ARRAYS SET'/' IN THE SOURCE CODE',
      >           'YOU NEED TO ACCESS SOURCE CODE AND MAKE CHANGES')
        go to 999
      endif
      c
      if (lhb .lt. 6) then
        write (*,9993)
9993  format ('DELTA.....GRID INTERVAL IN MAP UNITS (0.33 degrees)',
      >           'SHORTEST WAVELENGTH TO BE PASSED',
      >           'MUST BE AT LEAST 2*DELTA (0.66 degrees)',
      >           'LONG.....LONGEST WAVELENGTH TO BE PASSED',
      >           'MUST BE LARGER THAN SHORT ...no kidding',
      >           'CUTHI.....HIGHEST WAVENUMBER TO PASSED .LE. NYQUIST',
      >           'CUTLO.....LOWEST WAVENUMBER TO BE PASSED .GE. 0.0 AND',
      >           'LT. CUTHI',
      >           'NPASS.....-1 TO REJECT WAVELENGTHS BETWEEN SHORT',
      >           'AND LONG',
      >           '1 TO PASS WAVELENGTHS BETWEEN SHORT AND',
      >           'LONG',
      >           'NOTE : WAVENUMBER = 1/WAVELENGTH AND IS',
      >           'CALCULATED BY THE PROGRAM',
      >           'INPUT ORDER IS DELTA SHORT LONG NPASS')
      read (*,*) delta,short,long,npass
      write (*,9994)
9994  format ('NWIND..... TYPE OF WINDOW TO APPLY',
      >           '- 0 GIVES NO WINDOW',
      >           '- 1 RECTANGULAR WINDOW',
      >           '- 2 BARTLETT WINDOW (TRIANGULAR)',
      >           '- 3 HAMMING-TUKEY WINDOW',
      >           '- 4 PARZEN WINDOW',
      >           'XLAG..... SMOOTHING PARAMETER FOR WINDOWING IDEAL',
      >           'FILTER IN SPATIAL DOMAIN (95.0) (is disabled if',
      >           'no window was chosen above) .',
      >           'nwind xlag')
      read (*,*) nwind,xlag
      endif
      c
      if (lhb .ge. 2 .and. lhb .le. 5 .or. cc .eq. 1) then
        write (*,9995)
9995  format ('WHAT IS THE MINIMUM CORR COEF TO BE PASSED:(0.3)',
      >           'WHAT IS THE MAXIMUM CORR COEF TO BE PASSED:(1.0)',
      >           '0 DO NOT CHECK MATCH OF PASSNOS',
      >           '1 FOR PROGRAM TO CHECK MATCH OF PASSNOS',
      >           'MINIMUM INPUT CC WITHOUT WRITING WARNING',
      >           'MAXIMUM INPUT CC WITHOUT WRITING WARNING',
      >           'CNWIND..... TYPE OF WINDOW TO APPLY',
      >           '- 0 GIVES NO WINDOW'

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```

>      '      - 1 RECTANGULAR WINDOW'
>      '      - 2 BARTLETT WINDOW (TRIANGULAR)'
>      '      - 3 HAMMING-TUKEY WINDOW'
>      '      - 4 PARZEN WINDOW'
>      'CXLAG..... SMOOTHING PARAMETER FOR WINDOWING IDEAL'
>      '      FILTER IN SPATIAL DOMAIN (95.0) (is disabled if'
>      'no window was chosen above).//'
>      'mincc maxcc match minccin maxccin cnwind cxlag'
>      'read (*,*) mincc,maxcc,match,minccin,maxccin,cnwind,cxlag
>      'endif
>      'if (numfile .eq. 2) then
>      'write (*,*) 'AND FINALLY: 0 DO NOT SUBTRACT FILE1-FILE1 (use 0)'
>      'write (*,*) '1 TO WRITE A FILE OF TIME DOMAIN SUBTRACTION'
>      'write (*,*) 'OF FILE 3 = INPUT FILE 1 - OUTPUT FILE 1'
>      'read (*,*) isub
c----- isub equals 1 if you want to subtract
c           the filtered portions of file1 from the
c           input of file1. this option is not
c

often used.
      'endif
c
      'go to 200
c
100  'continue
      'read (22,*) numfile
      'read (22,*) lhb,cc
      'read (22,*) nobs,fold,prcnt,imean
      'read (22,*) delta,short,long,npass
      'read (22,*) nwind,xlag
      'read (22,*) mincc,maxcc,match,minccin,maxccin,cnwind,cxlag
      'read (22,*) isub
c
200  'continue
c
      'write (*,*) 'all input files must have a header with:'
      'write (*,*) 'row,column,zero,mean,pass number,eight'
      'write (*,*) 'zero... can be bogus but row and col are necessary'
      'write (*,*) 'INPUT FILE 1 (do not put guide function file here)'
      'read (*,9990) filename
9990  'format (a80)
      'open (10, file=filename,status='old',form='unformatted')
      'if (numfile .eq. 2) then
          'write (*,*) 'INPUT FILE 2 (or the guide function file)'
          'read (*,9990) filename
          'open (11, file=filename,status='old',form='unformatted')
      'endif
      'write (*,*) 'OUTPUT OF FILE 1'
      'read (*,9990) filename
      'open (20, file=filename,form='unformatted')
      'if (numfile .eq. 2) then
          'write (*,*) 'OUTPUT OF FILE 2'
          'read (*,9990) filename
          'open (21, file=filename,form='unformatted')
      'endif
      'write (*,*) 'OUTPUT FILE OF STATISTICS AND INFORMATION'
      'read (*,9990) filename
      'open (25, file=filename,form='formatted')
      'if (isub .eq. 1) then
          'write (*,*) 'OUTPUT FILE 3 OF SUBTRACTION'
          'read (*,9990) filename
          'open (23, file=filename, form='unformatted')
      'endif
c
      'if (lhb .lt. 6) then
          'cuthi=1.0/short
          'cutlo=1.0/long
          'RCUTLO=999999.99
          'IF(CUTLO .GE. 0.0000001 ) RCUTLO= 1.0/CUTLO
          'RCUTHI=1.0/CUTHI
          'WAVLEN=2.0*DELTA
          'FNQ1=1.0/WAVLEN
          'WRITE (25,9987) FNQ1,WAVLEN,CUTLO,RCUTLO,CUTHI,RCUTHI
9987  'FORMAT('NYQUIST WAVENUMBER ',F10.5,' CYCLES PER DATA INTERVAL',
      '      'NYQUIST WAVELENGTH = ',F10.5,' LENGTH INTERVALS',
      '      'LOW WAVE# CUTOFF OF IDEAL FILTER = ',F10.5,
      '      ' CYCLES PER DATA INTERVAL ',F15.5,
      '      ' WAVELENGTH EQUIVALENT',
      '      'HIGH WAVE# CUTOFF OF IDEAL FILTER = ',F10.5,
      '      ' CYCLES PER DATA INTERVAL ',F15.5,
      '      ' WAVELENGTH EQUIVALENT',//)
      'endif
c
      'gfcnt=0
210  'continue
      'read (10,end=999) xrow,xcol,zero,xmean,xpassno,eight
      'xobs=xrow
      'do 1=1,xrow

```

```

        read (10) xdata(i)
      enddo
230  if (numfile .eq. 2) then
        read (11,end=999) yrow,ycol,zero,ymean,ypassno,seven
        if (seven .eq. 7777) go to 500
        ynobs=yrow
        do i=1,yrow
          read (11) ydata(i)
        enddo
      endif
c
      if (isub .eq. 1) then
        do i=1,xrow
          strxdata(i)=xdata(i)
        enddo
      endif
c
      xmean=0.0
      call forwardft (1,xmean,xpassno)
      ymean=0.0
      if (numfile .eq. 2) call forwardft (2,ymean,ypassno)
c
      if (lhb .le. 3) then
        call filter (1)
        if (numfile .eq. 2) call filter (2)
      endif
c
      if (lhb .ge. 2 .and. lhb .le. 5 .or. cc .eq. 1) then
        call correlate(xpassno,ypassno)
      endif
c
      if (lhb .ge. 3 .and. lhb .le. 5) then
        call filter (1)
        if (numfile .eq. 2) call filter (2)
      endif
c
      if (lhb .eq. 5) call correlate(xpassno,ypassno)
c
      call inverseft (1,xmean,xpassno)
      if (numfile .eq. 2) call inverseft (2,ymean,ypassno)
c
c
500  write (20) xrow,xcol,zero,xmean,xpassno,eight
      do i=1,xrow
        write (20) xdata(i)
      enddo
      if (numfile .eq. 2) then
        write (21) yrow,ycol,zero,ymean,ypassno,seven
        if (seven .eq. 7777) then
          gfcnt=gfcnt+1
          go to 570
        endif
        do i=1,yrow
          write (21) ydata(i)
        enddo
570  if (isub .eq. 1) then
        if (seven .eq. 7777) then
          write (23) xrow,xcol,zero,xmean,xpassno,eight
          do i=1,xrow
            write (23) xdata(i)
          enddo
        elseif (seven .ne. 7777) then
          write (23) xrow,xcol,zero,xmean,xpassno,seven
          do i=1,xrow
            write (23) ( strxdata(i)-xdata(i) )
          enddo
        endif
      endif
      go to 210
c
999  continue
      if (gfcnt .gt. 0)
      >    write (*,*) 'total passes without a guide function =',gfcnt
      close (10)
      close (11)
      close (20)
      close (21)
      close (22)
      close (25)
      stop
      end
c
c
      subroutine forwardft (num,mean,passno)
      integer num,xnobs,ynobs,xynobs,nobs,passno
      real xdata(4096),ydata(4096),prcnt,mean
      complex xcdata(4096),ycdata(4096)

```

```

common /fftiifft/ nobs,prcnt,imean,fold
common /rowcol/ xnob,ynobs
common /reals/ xdata,ydata
common /comps/ xcdata,ycdata
COMMON H(4096)
DIMENSION X(2,4096)
COMPLEX H
double precision TSUM
EQUIVALENCE (X(1,1),H(1))

c
TSUM=0.D0
if (num .eq. 1) then
  xynobs=xnob
  do i=1,ynobs
    x(1,i) = xdata(i)
    tsum=tsum+x(1,i)
  enddo
elseif (num .eq. 2) then
  xynobs=ynobs
  do i=1,ynobs
    x(1,i) = ydata(i)
    tsum=tsum+x(1,i)
  enddo
endif

c
c----- subroutine description
c
c.....REQUIRED SUBROUTINES :
c
c      FFT1D, FORK, DATWND
c
c.....DIMENSIONING REQUIREMENTS :
c
c      X(2,N).....WHERE N IS THE NUMBER OF COLUMNS AND ROWS OF THE
c      H(N)      OUTPUT TRANSFORMED MATRIX. N MUST BE AN INTEGRAL
c      POWER OF TWO (2,4,8,16...).
c      NOTE : DIMENSIONS IN EVERY SUBROUTINE MUST BE
c      SET EQUAL TO DIMENSIONS IN MAIN PROGRAM.
c
c.....AUTHOR :SUBROUTINES FFT2D AND FORK ARE MODIFIED FROM JON REED,
c      PURDUE UNIVERSITY, DECEMBER 1980.
c      ALL OTHER CODE WRITTEN BY:
c      JEFFREY E. LUCIUS
c      GEOPHYSICAL INTERACTIVE COMPUTING LABORATORY
c      DEPARTMENT OF GEOLOGY AND MINERALOGY
c      THE OHIO STATE UNIVERSITY
c      COLUMBUS, OHIO 43210
c
c      MARCH 25, 1985 (REVISED DEC 5, 1986)
c
c      revised once again for DEC workstations on 6 APR 90 so that
c      that this beast is actually user friendly.
c      These revisions will almost always be lower case letters.
c
c      revised again (judas priest this is getting old) on
c      1 AUG 90 into this present format of all fourier programs
c      combined into this program. for a full listing of all
c      comments in the 6 APR 90 version, see that version. no
c      kidding.
c
c*****IF(2**INT ALOG(FLOAT(nobs))/ALOG(2.0)+0.01).NE.nobs) THEN
c      WRITE(6,1030)
c      STOP
c      ENDIF
c
c.....CALCULATE AND REMOVE THE MEAN
c
c      XMEAN1=TSUM/FLOAT(xynobs)
c      DO IY=1,xynobs
c        X(1,IY)=X(1,IY)-XMEAN1
c      enddo
c      WRITE(25,1020) XMEAN1
c
c.....WINDOW THE EDGES VIA DATWND
c
c      CALL DATWND (PRCNT,xynobs,nobs,fold)
c
c.....MATRIX IS NOW ZERO FILLED TO NXOUT BY NYOUT SIZE
c      CALCULATE AND REMOVE THE MEAN INTRODUCED BY TAPERING
c
c      TSUM=0.D0
c      DO IY=1,nobs
c        TSUM=TSUM+X(1,IY)
c      enddo
c      XMEAN2=TSUM/FLOAT(nobs)
c      DO IY=1,nobs

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        X(1,IY)=X(1,IY)-XMEAN2
      enddo
c      WRITE(25,1020) XMEAN2
      XMEAN=XMEAN2+XMEAN1
c      WRITE(25,1080) XMEAN
      write (25,*) passno,xmean1,xmean2,xmean
c
c.....TRANSFORM DATA TO THE WAVENUMBER DOMAIN
c
      CALL FFT1D (nobs,-1)
c
      mean=xmean
      if (num .eq. 1) then
        do ix=1,nobs
          xcdata(ix) = h(ix)
        enddo
      elseif (num .eq. 2) then
        do ix=1,nobs
          ycdata(ix) = h(ix)
        enddo
      endif
c
      return
c
1020 FORMAT('MEAN REMOVED ',F15.7)
1030 FORMAT(1H , 'nobs MUST BE A POWER OF 2: SPA2FRQ FATAL')
1080 FORMAT('TOTAL MEAN REMOVED ',F15.7)
c
      END
c
c*****SUBROUTINE FFT1D (nobs,NSIGN)
c
c*****"FFT1D" PERFORMS BOTH A FORWARD OR INVERSE FAST FOURIER
c      TRANSFORM. "FFT1D" IS THE DRIVER THAT PASSES THE CORRECT VECTORS
c      TO "FORK" WHICH PERFORMS THE ACTUAL TRANSFORMING.
c      THE DIMENSIONING OF "H" MUST BE THE SAME AS IN THE MAIN PROGRAM
c
c      "nobs"      = NUMBER OF fft observations IN DATA MATRIX
c      "NSIGN"     = DIRECTION OF DESIRED TRANSFORMATION
c                  =+1  INVERSE TRANSFORM (FREQUENCY TO SPATIAL)
c                  =-1  FORWARD TRANSFORM (SPATIAL TO FREQUENCY)
c
c*****COMMON H(4096)
c      COMPLEX H
c
c      SIGNI=FLOAT(NSIGN)
c      IF (IABS(NSIGN).NE.1) THEN
c        WRITE(6,105)
c        STOP
c      ENDIF
c
c      CALL FORK (nobs,H,SIGNI)
c
c      RETURN
105  FORMAT(5X,'"NSIGN" MUST EQUAL +1 OR -1 FOR "FFT2D", FATAL')
c
c*****SUBROUTINE FORK (LXX,CX,SIGNI)
c
c*****FAST FOURIER TRANSFORM, MODIFIED FROM CLAERBOUT, J.F., FUNDAMENTAL
c      OF GEOPHYSICAL DATA PROCESSING, McGRAW-HILL, 1976
c      FORK USES COOLEY-TUKEY ALGORITHM.
c
c      "CX"      = DATA VECTOR TO BE TRANSFORMED
c      "LXX"     = LENGTH OF DATA VECTOR "CX" TO BE TRANSFORMED,
c                  MUST BE A POWER OF 2 (LXX=2**INTEGER)
c      "SIGNI"   = DIRECTION OF DESIRED TRANSFORMATION
c                  =+1.  INVERSE TRANSFORM (FREQUENCY TO SPATIAL)
c                  =-1.  FORWARD TRANSFORM (SPATIAL TO FREQUENCY)
c
c      NORMALIZATION PERFORMED BY DIVIDING BY
c      DATA LENGTH UPON THE FORWARD TRANSFORM.
c
c*****COMPLEX CX (LXX),CW,CTEMP,CON2
c
c      LX=LXX
c      LXH=LX/2
c      J=1
c      DO 103 I=1,LX

```

```

102      IF (I.LT.J) THEN
103          CTEMP=CX(J)
104          CX(J)=CX(I)
105          CX(I)=CTEMP
106      ENDIF
107      M=LXH
108      IF (J.GT.M) THEN
109          J=J-M
110          M=M/2
111          IF (M.GE.1) GO TO 102
112      ENDIF
113      J=J+M
114  CONTINUE
115      L=1
116  104      ISTEP=2*L
117      CON2=(0.0, 3.14159265)/FLOAT(L)*SIGNI
118      DO 105 M=1,L
119          CW=CEXP(CON2*FLOAT(M-1))
120          DO 105 I=M, LX, ISTEP
121              CTEMP=CW*CX(I+L)
122              CX(I+L)=CX(I)-CTEMP
123          CX(I)-CX(I)+CTEMP
124      L=ISTEP
125      IF (L.LT.LX) GO TO 104
126      IF (SIGNI.GT.0.0) RETURN
127          SC=1./FLOAT(LX)
128
129      DO 106 I=1,LX
130          CX(I)=CX(I)*SC
131
132      RETURN
133  END
134
135  ***** SUBROUTINE DATWND (PRCNT,xynobs,nobs,fold)
136  integer xynobs
137
138  ***** "DATWND" MULTIPLIES THE INPUT F(1,xynobs) BY A HALF BELL OF A HAMMING
139  ***** TUKEY WINDOW ON ALL EDGES AND ZEROS OUT THE REMAINDER OF THE
140  ***** (NX,NY) ARRAY.
141
142  ***** "PRCNT" =PERCENTAGE OF DATA TO BE ALTERED IN SMOOTHING TO ZERO
143  ***** 0.0 .LT. "PRCNT" .LE. 50.0
144
145  ***** update 2 feb 91
146  ***** dat wnd has been considerably improved such that now the subroutine
147  ***** performs three (count them, three !!) functions. one; a percentage
148  ***** of the input matrix can be folded out. two; after folding out,
149  ***** a new percentage of the folded out matrix (or regular data if
150  ***** folding was not performed) can be smoothed to zero. three; the
151  ***** manipulated data is centered within zeros to finish filling the
152  ***** matrix to nx by ny size. because the actual data is now centered
153  ***** within the transformed array, it is necessary to use the
154  ***** do loops in subroutine inverseft to correctly extract the actual
155  ***** data
156
157  ***** dimension holdme(4096)
158  ***** COMMON F(2,4096)
159
160  *****----- fold out the data based on percentage
161
162  ***** nx1=xynobs
163  ***** if (fold.gt.0.0 .and. fold.lt.100.0) then
164  *****     KX=Int(fold*FLOAT(xynobs)/100.0+0.5)
165  *****     if (kx>xynobs .gt. nobs) kx=(nobs-xynobs)/2
166  *****     do i=1,xynobs
167  *****         holdme(i)=f(1,i)
168  *****     enddo
169  *****----- fold out the observations
170  *****     do i=1,xynobs+kx+kx
171  *****         if (i.le.kx) f(1,i)=holdme(kx-i+1)
172  *****         if (i.gt.kx .and. i.le.(kx+xynobs)) f(1,i)=holdme(i-kx)
173  *****         if (i.gt.(kx+xynobs)) f(1,i)=holdme((2*xynobs+kx+1-i))
174  *****     enddo
175  *****     nx1=xynobs+2*kx
176  *****     endif
177
178  *****     if (prcnt.gt.0.0 .and. prcnt.lt.50.0) then
179  *****         KX=IFIX(PRCNT*FLOAT(NX1)/100.0+0.5)
180
181  *****         IF (KX.NE.0) THEN
182  *****             RKKPI= 3.14159265/FLOAT(KX)
183  *****             DO IX=1,KX
184  *****                 FACTOR=0.5*(1.0+COS(FLOAT(KX-IX+1)*RKKPI))
185  *****                 IXX=NX1-IX+1
186  *****                 F(1,IXX)=F(1,IXX)* FACTOR
187
188  *****             ENDIF
189
190  *****         ENDIF
191
192  *****         IF (KX.NE.0) THEN
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199  *****             ENDIF
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564  *****         ENDIF
565
566  *****         IF (KX.NE.0) THEN
567  *****             RKKPI= 3.14159265/FLOAT(KX)
568  *****             DO IX=1,KX
569  *****                 FACTOR=0.5*(1.0+COS(FLOAT(KX-IX+1)*RKKPI))
570  *****                 IXX=NX1-IX+1
571  *****                 F(1,IXX)=F(1,IXX)* FACTOR
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573  *****             ENDIF
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931  *****                 IXX=NX1-IX+1
932  *****                 F(1,IXX)=F(1,IXX)* FACTOR
933
934 
```

```

        enddo
        ENDIF
C       WRITE(25,150) KX, KY
C          write (25,*) kx,ky
        endif
C.....center and ZERO OUT REMAINDER OF ARRAY IF NECESSARY
C
        nxhalf=(nobs-nx1)/2
        do i=1,nx1
          holdme(i)=f(i,1)
        enddo
        do i=1,nxhalf
          f(i,1)=0.0
        enddo
        do i=nxhalf+1,nxhalf+nx1
          f(i,1)=holdme(i-nxhalf)
        enddo
        do i=nxhalf+nx1+1,nobs
          f(i,1)=0.0
        enddo
C
        RETURN
C
150  FORMAT('smoothed',14,' values on both x edges',/
>           '           ',14,'           y           ')
C
        END
C
C
        subroutine filter (num)
        integer num,npass,imean,nwind,nobs
        real prcnt,xlag,delta,cuthi,cutlo
        complex xcdata(4096),ycdata(4096),cdata(4096)
        common /rowcol/ xnobs,ynobs
        common /fftfilt/ nobs,prcnt,imean,fold
        common /comps/ xcdata,ycdata
        common /hbfilter/ delta,cuthi,cutlo,xlag,npass,nwind
        COMMON H(4096)
        COMPLEX H
        DIMENSION D1(2,4096)
        EQUIVALENCE (D1(1,1),H(1))
C
        if (num .eq. 1) then
          do i=1,nobs
            cdata(i) = xcdata(i)
          enddo
        elseif (num .eq. 2) then
          do i=1,nobs
            cdata(i) = ycdata(i)
          enddo
        endif
C*****
C
C
        PROGRAM BANDPASS
C
C
        PROGRAM BANDPASS PERFORMS HIGH, LOW, OR BANDPASS WAVENUMBER
C
        FILTERING OF UNIFORMLY GRIDDED ARRAYS. AN IDEAL FILTER
C
        IS CONSTRUCTED IN THE WAVENUMBER DOMAIN, WINDOWED IN THE SPACE
C
        DOMAIN, THEN TRANSFORMED BACK INTO THE WAVENUMBER DOMAIN TO BE
C
        MULTIPLIED BY THE INPUT TRANSFORM.
C
C.....REQUIRED SUBROUTINES :
C
C      BNDPAS, FFT2D, FORT, STORE, WINDOW
C
C.....DIMENSIONING REQUIREMENTS :
C
C      D1(2,N).....WHERE N IS THE NUMBER OF observations OF THE
C      H(N)      INPUT AND OUTPUT TRANSFORMED MATRIX. N MUST BE AN
C      INTEGRAL POWER OF TWO (2,4,8,16...).
C      NOTE : DIMENSIONS IN EVERY SUBROUTINE MUST BE
C      SET EQUAL TO DIMENSIONS IN MAIN PROGRAM.
C
C.....AUTHOR : JON REED, PURDUE UNIVERSITY, DECEMBER 1980.
C      REVISIONS BY STEVE MATESKON AND JEFF LUCIUS,
C      OHIO STATE UNIVERSITY, JULY 1984.
C
C
C      this program, like others in the fft series, has been updated
C      to the DEC workstation system and now the program is actually
C      usable to just about anybody! revised 21 apr 90
C
C
C      well, like the other programs in this package, this has been
C      updated on 4 AUG 90. few comments have been removed - mainly
C      those comments about i/o operations not necessary to this
C      package have been removed.
C

```

```

c      update: 2 feb 90, removed need for cstore array
c
c
C*****CREATE IDEAL CONTINUATION FILTER AND STORE IN ARRAY H
C
C      CALL BNDPAS (CUTLO,CUTHI,NPASS,DELTA,nobs)
C
C.....CREATE SMOOTHED FILTER
C
C      IF (XLAG.GT.0.0 .AND. XLAG.LE.100.0) THEN
C          IF (NWIND.GT.0.AND.NWIND.LE.4) THEN
C              CALL FFTID (nobs,1)
C              CALL WINDOW (nobs,XLAG,NWIND)
C              CALL FFTID (nobs,-1)
C          ENDIF
C      ENDIF
C
C.....WRITE FILTER (WAVENUMBER DOMAIN) ONTO UNIT 30 IF IOFIL = 1
C
C      IF (IOFIL.EQ.1) THEN
C          WRITE (30,*) nobs,IZERO,XMEAN
C          WRITE (30,*) (H(IX),IX=1,nobs)
C      ENDIF
C
C      if (num .eq. 1) then
C          do i=1,nobs
C              xcdata(i) = cdata(i)*h(i)
C          enddo
C      elseif (num .eq. 2) then
C          do i=1,nobs
C              ycdata(i) = cdata(i)*h(i)
C          enddo
C      endif
C
C      return
C
C*****SUBROUTINE BNDPAS (CCUTLO,CCUTHI,NPASS,DELTA,nobs)
C
C*****"BNDPAS" CALCULATES THE WAVE# RESPONSE OF AN IDEAL BANDPASS
C      FILTER OF A (nobs) MATRIX. ARRAY "H" MUST BE DIMENSIONED THE
C      SAME AS IN THE MAIN PROGRAM
C
C "CCUTLO"    LOWEST WAVE# TO BE PASSED, GE 0.0
C "CCUTHI"    HIGHEST WAVE# TO BE PASSED, LE NYQUIST
C "NPASS"     SWITCHES EITHER A PASS OR REJECTION BETWEEN
C             "CUTLO" & "CUTHI"
C             --1 REJECT WAVENUMBERS BETWEEN THE 2 WAVENUMBERS
C             - 1 PASS  WAVENUMBERS BETWEEN THE 2 WAVENUMBERS
C "DELTA"     DATA GRID INTERVAL, IN MAP UNITS
C nobs        number of fft observations
C
C*****COMMON H(4096)
C      COMPLEX H,ZERO,ONE
C
C      CUTHI=CCUTHI
C      CUTLO=CCUTLO
C      RCUTLO=999999.99
C      IF (CUTLO.GE. 0.000001 ) RCUTLO= 1.0/CUTLO
C      RCUTHI=1.0/CUTHI
C      WAVLEN=2.0*DELTA
C      FNQ1=1.0/WAVLEN
C      WRITE (25,112) FNQ1,WAVLEN,CUTLO,RCUTLO,CUTHI,RCUTHI,NPASS
C
C      IF (IABS(NPASS).NE.1) THEN
C          WRITE (6,151)
C          STOP
C      ENDIF
C      IF (CUTHI.GT.FNQ1.OR.CUTHI.LE.CUTLO.OR.CUTLO.LT.0.0) THEN
C          WRITE (6,151)
C          STOP
C      ENDIF
C
C      NXX=nobs+2
C      NX2=(nobs/2)+1
C      ZERO = (0.0,0.0)
C      ONE  = (1.0,0.0)
C      IF (NPASS.NE.1) THEN
C          ZERO = (1.0,0.0)
C          ONE  = (0.0,0.0)
C      ENDIF
C

```

```

CLOWX=FLOAT (NX2)*WAVLEN*CUTLO
CHIX =FLOAT (NX2)*WAVLEN*CUTHI
C
C....."ZERO" OUT THE entire ARRAY
C
DO IX=1,nobs
  H(IX) = ZERO
enddo
C
C.....OPERATE ON ROWS WHERE WAVENUMBERS ARE .LE. CUTLO
C
MINS=1
MAXS=NX2
IF(CUTLO.GT.0.000001) MINS= int(clowx + 2.0001)
IF(FNQ1-CUTHI.GT.0.000001) MAXS=int(chix + 1.0001)
if (mins .le. maxs) then
  DO IX=MINS,MAXS
    H(NXIX)= ONE
    H(IX)= ONE
  enddo
ENDIF
C
RETURN
C
112  FORMAT(1X,'NYQUIST WAVENUMBER =',F10.5,'CYCLES PER DATA INTERVAL'
>      ,1X,'NYQUIST WAVELENGTH =',F10.5,' LENGTH INTERVALS'
>      ,1X,'LOW WAVE# CUTOFF OF IDEAL FILTER = ',F10.5,
>      ' CYCLES PER DATA INTERVAL',3X,F15.5,' WAVELENGTH EQUIVALENT'
>      ,1X,'HIGH WAVE# CUTOFF OF IDEAL FILTER = ',F10.5,
>      ' CYCLES PER DATA INTERVAL',3X,F15.5,
>      ' WAVELENGTH EQUIVALENT',/1X,'NPASS= ',I1//)
151  FORMAT(5X , 'IMPOSSIBLE FILTER CONSTRUCTION IS SPECIFIED. FATAL')
C
END
C
C*****
C
C      SUBROUTINE WINDOW (nobs,XLAG,NWIND)
C
C*****
C "WINDOW" PERFORMS 1-DIMENSION WINDOWING OVER the DATA ARRAY
C EACH QUAD. IS SEPARATELY WINDOWED. THE 1.0 COEFFICIENT IS ALWAYS
C THE OUTER MOST CORNER OF THE ARRAY.
C
C "nobs"      = NUMBER OF observations IN DATA MATRIX
C "XLAG"       = SMOOTHING PARAMETER FOR WINDOWING IDEAL FILTER IN SPATIAL *
C                  DOMAIN. DETERMINES WHAT PERCENTAGE OF DATA IS WINDOWED *
C                  (nobs*XLAG/100.0) THE REMAINDER IS SET TO 0.0. I.E. THE *
C                  SMALLER "XLAG" THE SMOOTHER THE WINDOWING. *
C
C "XLAG" MUST BE .GT. 0.0 AND. LE. 100.0 FOR WINDOWING *
C
C      VALUES OUTSIDE OF THIS RESULTS IN NO WINDOWING *
C      THE SMALLER THE "XLAG" THE SMOOTHER THE FILTER. *
C
C "NWIND"      = TYPE OF WINDOW TO APPLY
C                  -0 GIVES NO WINDOW
C                  -1 gives a rectangular window
C                  -2 GIVES BARTLETT WINDOW (TRIANGLE WINDOW)
C                  -3 GIVES HAMMING-TUKEY WINDOW
C                  -4 GIVES PARZEN WINDOW
C
C*****
C
C      COMMON H(4096)
C      COMPLEX H
C
LAG=FLOAT(nobs)*XLAG/200.0+0.5
LAG=AMAX0 (LAG, 2)
PI=3.14159265
NXN=nobs+2
NX2=(nobs/2)+1
XNMR=FLOAT (NX2)
XNX=1.0/FLOAT (NX2)
C
RADIUS=FLOAT (LAG)*XNX
RADI=1.0/RADIUS
RAD2= RADIUS*RADIUS
C
C.....APPLY RECTANGULAR WINDOW TO FILTER
C
IF (NWIND.EQ.1) THEN
  MAX=int (RADIUS*XNMR+1.0001)
  LL=MAX+1
  DO II=LL,NX2
    H(NXIX)-(0.0,0.0)
    H(II)-(0.0,0.0)
  enddo
C
  WRITE(25,660) XLAG,LAG
  RETURN
C

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C.....APPLY BARTLETT WINDOW TO FILTER
C
ELSEIF (NWIND.EQ.2) THEN
  MAX=RADIUS*XNKR+1.0001
  IF (MAX.GE.2) THEN
    DO 253 LL=2,MAX
      XI=FLOAT(LL-1)*XNX
      FACTOR=1.0-XI*RADI
      H(LL)=H(LL)*FACTOR
      MX=NXX-LL
  253  H(MX)=H(MX)*FACTOR
  ENDIF
C
  LL=MAX+1
  DO 255 II=LL,NX2
    H(NXX-II)=(0.0,0.0)
  255  H(II)=(0.0,0.0)
C
c      WRITE (25,661) XLAG,LAG
  RETURN
C
C.....APPLY HAMMING-TUKEY WINDOW TO FILTER
C
ELSEIF (NWIND.EQ.3) THEN
  PIRADI=PI*RADI
  MAX=RADIUS*XNKR+1.0001
  IF (MAX.GE.2) THEN
    DO 353 LL=2,MAX
      XI=FLOAT(LL-1)*XNX
      FACTOR=0.5*(1.0+COS(PIRADI*XI))
      H(LL)=H(LL)*FACTOR
      MX=NXX-LL
  353  H(MX)=H(MX)*FACTOR
  ENDIF
C
  LL=MAX+1
  DO 355 II=LL,NX2
    H(NXX-II)=(0.0,0.0)
  355  H(II)=(0.0,0.0)
C
c      WRITE (25,662) XLAG,LAG
  RETURN
C
C.....APPLY PARZEN WINDOW TO FILTER
C
ELSEIF (NWIND.EQ.4) THEN
  MAX=RADIUS*XNKR+1.0001
  MAX2=SQRT(RAD2/4.0)*XNKR+1.0001
  FACTOR=1.0-6.0*((XI*RADI)**2-(XI*RADI)**3)
  H(1)=H(1)*FACTOR
C
  IF (MAX2.GE.2) THEN
    DO 453 LL=2,MAX
      XI=FLOAT(LL-1)*XNX
      FACTOR=1.0-6.0*((XI*RADI)**2-(XI*RADI)**3)
      H(LL)=H(LL)*FACTOR
      MX=NXX-LL
  453  H(MX)=H(MX)*FACTOR
  ENDIF
C
  KOUNT=MAX2+1
  DO 457 LL=KOUNT,MAX
    XI=FLOAT(LL-1)*XNX
    FACTOR=2.0*(1.0-(XI*RADI))**3
    H(LL)=H(LL)*FACTOR
    MX=NXX-LL
  457  H(MX)=H(MX)*FACTOR
  LL=MAX+1
  DO 455 II=LL,NX2
    H(NXX-II)=(0.0,0.0)
  455  H(II)=(0.0,0.0)
C
c      WRITE (25,663) XLAG,LAG
  RETURN
C
C.....DO NOT APPLY A WINDOW TO FILTER
C
ELSEIF (NWIND.EQ.0) THEN
  WRITE (25,664)
ENDIF
C
  RETURN
C
660  FORMAT ('RECTANGULAR WINDOW USED XLAG= ',F7.3,4X,'LAG= ',I5)
661  FORMAT ('BARTLETT WINDOW USED XLAG= ',F7.3,4X,'LAG= ',I5)
662  FORMAT ('HAMMING-TUKEY WINDOW USED XLAG= ',F7.3,4X,'LAG= ',I5)
663  FORMAT ('PARZEN WINDOW USED XLAG= ',F7.3,4X,'LAG= ',I5)
664  FORMAT ('NO WINDOWING HAS BEEN APPLIED ; XLAG= ',F7.3)
C
END

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c
c subroutine correlate(xpassno,ypassno)
integer xnobs,ynobs,nobs,match,xpassno,ypassno,
>      zerocont(4096),cnwind
real mincc,maxcc,ccwinout,prcnt,
>      pctptr3,pctptr4,minccin,maxccin,cxlag
complex h(4096),power5,power6,totpwr
COMPLEX X(4096),Y(4096),zero,
>      POWER1,POWER2,POWER3,POWER4,XPOWER,TPOWER
REAL CCOEF,CCIN,CCOUT
DATA ZERO/(0.000000,0.000000)/
common /rowcol/ xnobs,ynobs
common /comps/ x,y
common /ccfilt/ mincc,maxcc,match,minccin,maxccin,cnwind,cxlag
common /fftifft/ nobs,prcnt,imean,fold
common h

c----- subroutine description
c
c correlate finds the correlation coefficient between each
c wavenumber component of the two input arrays. each cc is
c normalized to range between -1.0 through 0.0 to 1.0. the
c cc is the cosine of the phase angle difference between two
c wavenumber components.
c
c revisions:
c
c well, by now you know the story... revised 4 AUG 90
c i've added the windowing functions available from the
c bandpassing subroutines to this cc-filter. try them if
c you like!
c
c updates 1 feb 91: change calculation of correlation
c coefficient from a summation based formula to the cosine of
c the phase angle difference.
c
c
if (match .eq. 1) then
  if (xpassno .ne. ypassno) then
    write (*,*) 'NO MATCH BETWEEN PASS NUMBERS',xpassno,ypassno
  endif
endif
if (xnobs .ne. ynobs ) then
  write (*,*) 'NO MATCH BETWEEN NUMBER OF OBSERVATIONS'
  write (*,*) 'CORRELATION COEF MAY NOT BE CORRECT'
  write (*,*) 'PASSNUMBERS',xpassno,ypassno
  write (*,*) 'FILE 1: OBSERVATIONS =',xnobs
  write (*,*) 'FILE 2: OBSERVATIONS =',ynobs
endif
c
pi=3.141592654
twopi=6.283185307
POWER1=ZERO
POWER2=ZERO
POWER3=ZERO
POWER4=ZERO
XPOWER=ZERO
TPOWER=ZERO
c
DO 110 i=1,nobs
c----- zerocont array is a flagging array used to
c set the windowing array h to equal
c (0.0,0.0) or (1.0,0.0). a little inspection
c of subroutine BNDPAS will help illuminate
c the principle.
zerocont(i)=1
c
c SUM THE POWERS & CROSS PRODUCTS OF THE INPUT MAPS.
c
POWER1=POWER1+(X(I)*CONJG(X(I)))
POWER2=POWER2+(Y(I)*CONJG(Y(I)))
XPOWER=XPOWER+(X(I)*CONJG(Y(I)))
c
c----- xrad is the phase angle of the x array wavenumber and
c yrad is the phase angle of the y array wavenumber. the
c cosine of the minimum phase difference is the correlation
c of the two wavenumbers. to find the minimum phase difference
c it is necessary to adjust xrad or yrad with integer values
c of pi. so....do not change the order of the if statements !!
xrad=atan(aimag(x(i))/(real(x(i))))
if (real(x(i)).lt.0.0) xrad=xrad+pi
if (aimag(x(i)).lt.0.0) xrad=xrad+twopi
yrad=atan(aimag(y(i))/(real(y(i))))
if (real(y(i)).lt.0.0) yrad=yrad+pi
if (aimag(y(i)).lt.0.0) yrad=yrad+twopi
delrad=abs(xrad-yrad)
cccoef=cos(delrad)
c

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      IF (CCOEF .GT. maxcc .or. CCOEF .LT. mincc) THEN
        X(I)=ZERO
        Y(I)=ZERO
        zerocont(i)=0
      ENDIF
      C
      C  SUM THE POWERS & CROSS PRODUCTS FOR THE OUTPUT MAPS.
      C
      POWER3=POWER3+(X(I)*CONJG(X(I)))
      POWER4=POWER4+(Y(I)*CONJG(Y(I)))
      TPOWER=TPOWER+(X(I)*CONJG(Y(I)))
      110  CONTINUE
      C
      C  CALCULATE THE C.C. FOR THE INPUT MAPS.
      C
      if (power1 .eq. zero .or. power2 .eq. zero) then
        write (*,*) 'power1 =',power1,xpassno
        write (*,*) 'power2 =',power2,ypassno
        ccin=9999.9
      else
        CCIN=REAL(XPOWER/SQRT(POWER1*POWER2))
      endif
      C
      C  CALCULATE THE C.C. FOR THE OUTPUT MAPS.
      C
      if (power3 .eq. zero .or. power4 .eq. zero) then
        write (*,*) 'power3 =',power3,xpassno
        write (*,*) 'power4 =',power4,ypassno
        ccout=9999.9
      else
        CCOUT=REAL(TPOWER/SQRT(POWER3*POWER4))
      endif
      C
      C  CALCULATE THE PERCENTAGE OF THE POWER RETAINED IN THE FILTERED
      C  MAPS.
      C
      if (power1 .eq. zero .or. power2 .eq. zero) then
        pctpr1=9999.9
        pctpr2=9999.9
      else
        PCTPR1=(POWER3/POWER1)*100.0
        PCTPR2=(POWER4/POWER2)*100.0
      endif
      C
      C  WRITE THE C.C. FOR THE INPUT & OUTPUT MAPS TO FILE 6.
      C
      WRITE (6,444) CCIN
      WRITE (6,555) CCOUT
      C
      C  WRITE THE POWER PERCENTAGES TO FILE 6.
      C
      WRITE (6,666) PCTPR1,PCTPR2
      c 444  FORMAT (' ''THE CORRELATION COEFFICIENT BETWEEN THE INPUT '
      *   ',MAPS IS ',F6.3)
      c 555  FORMAT (' ''THE CORRELATION COEFFICIENT BETWEEN THE OUTPUT '
      *   ',MAPS IS ',F6.3)
      c 666  FORMAT (' ''THE PERCENTAGE OF THE TOTAL POWER IN MAP ONE',
      *   ', PASSED IS',F7.3,'%',/, ' THE PERCENTAGE OF THE TOTAL POWER',
      *   ', IN MAP TWO PASSED IS',F7.3,'%')
      C
      C
      write (25,888) xpassno,ypassno,ccin,ccout,pctpr1,pctpr2
      888 format (216,4f10.3)
      if (ccin .lt. minccin) write (*,*)xpassno,ypassno,ccin,' <min'
      if (ccin .gt. maxccin) write (*,*)xpassno,ypassno,ccin,' >max'
      C
      C----- the following if statement controls
      C----- the windowing functions for smoothing
      C----- the output arrays and calculates a new
      C----- output correlation coefficient and
      C----- percents of power retained in the
      C----- windowed arrays because
      C----- the data will change slightly with
      C----- windowing
      C
      if (cnwind .ge. 1 .and. cnwind .le. 4) then
        power5=zero
        power6=zero
        totpwr=zero
        do i=1,nobs
          h(i)=(1.0,0.0,0)
          if (zerocont(i) .eq. 0) h(i)=(0.0,0.0,0)
        enddo
        call fft1d (nobs,1)
        call window (nobs,cxlag,cnwind)
        call fft1d (nobs,-1)
        do i=1,nobs
          x(i)=x(i)*h(i)
          y(i)=y(i)*h(i)
          power5=power5+(x(i)*conjg(x(i)))

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        power6=power6+(y(i)*conjg(y(i)))
        totpwr=totpwr+(x(i)*conjg(y(i)))
    enddo
    if (power5 .eq. zero .or. power6 .eq. zero) then
        write (*,*) 'power5 =',power5,xpassno
        write (*,*) 'power6 =',power6,ypassno
        ccwinout=9999.9
        go to 340
    endif
    if (power1 .eq. zero .or. power2 .eq. zero) then
        pctpr3=9999.9
        pctpr4=9999.9
        go to 340
    endif
    ccwinout=real(totpwr/sqrt(power5*power6))
    pctpr3=(power5/power1)*100.0
    pctpr4=(power6/power2)*100.0
340    continue
        write (25,888) xpassno,ypassno,ccin,ccwinout,pctpr3,pctpr4
c 888    format (216,4f10.3)
    endif
c
    return
end
c
c
c
subroutine inverseft (num,mean,passno)
integer num,xnobs,ynobs,xynobs,row,col,passno
real xdata(4096),ydata(4096),mean
complex xcdata(4096),ycdata(4096)
common /rowcol/ xnobs,ynobs
common /reals/ xdata,ydata
common /comps/ xcdata,ycdata
common /fftifft/ nobs,prcnt,imean,fold
COMMON H(4096)
DIMENSION X(2,4096),holdme(4096)
COMPLEX H
EQUIVALENCE (X(1,1),H(1))
c
if (num .eq. 1) then
    xynobs=xnobs
    do i=1,nobs
        h(i) = xcdata(i)
    enddo
elseif (num .eq. 2) then
    xynobs=ynobs
    do i=1,nobs
        h(i) = ycdata(i)
    enddo
endif
c
c-----subroutine description
c.....REQUIRED SUBROUTINES :
c
c       FFT1D, FORTK
c
c.....DIMENSIONING REQUIREMENTS :
c
c       X(2,N).....WHERE N IS THE NUMBER OF COLUMNS AND ROWS OF THE
c       H(N)          OUTPUT TRANSFORMED MATRIX. N MUST BE AN INTEGRAL
c                   POWER OF TWO (2,4,8,256...).
c                   NOTE : DIMENSIONS IN EVERY SUBROUTINE MUST BE
c                   SET EQUAL TO DIMENSIONS IN MAIN PROGRAM.
c
c.....AUTHOR : JEFF LUCIUS
c           DEPARTMENT OF GEOLOGY AND MINERALOGY
c           OHIO STATE UNIVERSITY, DECEMBER 1984.
c
c       revised: 8 AUG 90
c       updated: 2 feb 91
c           added do loops that find the data portion of the
c           zero centered inverse transformed data. a look at
c           subroutine datwnd will help figure this out.
c
c
c.....INVERSE TRANSFORM DATA TO THE SPACE DOMAIN
c
    CALL FFT1D (nobs,+1)
c
    nxhalf=(nobs-xynobs)/2
    do i=nxhalf+1,nxhalf+xynobs
        holdme(i-nxhalf)=x(1,i)
    enddo
c
    total=0.0
    DO I=1,xynobs
        x(1,i)=holdme(i)
        total=total+x(1,i)
    enddo
    xmean=total/float(xynobs)

```

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      IF (IMEAN .EQ. 1) THEN
        do i=1,xynobs
          x(1,i)=x(1,i)+mean
        enddo
      ENDIF
      C
      XMIN= 1.0E20
      XMAX=-1.0E20
      if (num .eq. 1) then
        do i=1,xynobs
          xdata(i) = x(1,i)
        enddo
      elseif (num .eq. 2) then
        do i=1,xynobs
          ydata(i) = x(1,i)
        enddo
      endif
      DO I=1,xynobs
        XMIN=AMIN1 (XMIN,X(1,I))
        XMAX=AMAX1 (XMAX,X(1,I))
        IF (XMAX.EQ.X(1,I)) IMAX=I
        IF (XMIN.EQ.X(1,I)) IMIN=I
      enddo
      C
      WRITE (25,1020) XMAX,IMAX,XMIN,IMIN,xmean,passno
      write (25,9980) passno,xmean,xmax,imax,xmin,imin
      9980 format (15,2x,f13.5,2x,f13.5,2x,14,f13.5,2x,14)
      C
      1020 FORMAT('MAXIMUM OF IFFT = ',E15.7,' AT (',I3,')',/
                 >      'MINIMUM = ',E15.7,' AT (',I3,')',/
                 >      'MEAN AFTER IFFT = ',e15.7,' FOR PASS',16,/)
      C
      return
      END

```



```

program combine
  integer xrow, xcol, zero, eight, xpassno, ypassno, ycol,
  >      x3row, x3col, x3pass, y3row, y3col, y3pass, yrow,
  >      strcnt, syrow, sy3row, sycol, sy3col, nobs, noc,
  >      sypassno, sy3pass, dndk, tcount, parent, minobs,
  >      paircnt1, choice, totobs, prime, global, crosscnt,
  >      passrem, nowant(4000), nocnt, type
  real xmean, ymean, x3data(400,3), y3data(400,3), y3mean,
  >      x3data(400), y3data(400), xadata(400,4), ybdata(400,4),
  >      x3mean, sy3mean, symean, x(400), y(400),
  >      saveyl(400), savey3(400,3), xamean,
  >      ybmean, avgdata(400,4)
  character*80 filename
  common /trunstat/ xadata(400,4), ybdata(400,4)
  common x3data(400,3), x1data(400), y3data(400,3), y1data(400)
  common /aver/ avgdata(400,4)
  common /tplot/ x(400), y(400)
  common /nope/ nowant(4000), nocnt
c
c----- program description
c
c      combine is very similar to movetrunc in that both
c      programs truncate adjacent passes to the same over-
c      lapping segments. both programs also provide
c      statistics and track output files. the major
c      difference is that movetrunc has only one file
c      as input whereas combine has two files as input.
c      combine can output one file of two passes averaged
c      together to make the one file or it can output
c      two similar length passes that can be further
c      processed by fourier methods. movetrunc and combine
c      could be glued together to make one program
c      so why don't you go ahead and jam them together??
c      good luck!!
c
c      program date: 16 apr 91
c
  write (*,*) '1 TO HAVE ONE OUTPUT FILE'
  write (*,*) '2 TO HAVE TWO OUTPUT FILES'
  read (*,*) ifilenum
  if (ifilenum .eq. 2) then
    prime=1
    goto 3
  endif
  write (*,*) '1 TO AVERAGE A-east AND A-west'
  write (*,*) '2 TO AVERAGE A-east AND B-west (choose 2)'
  read (*,*) prime
  3  write (*,*) '0 IF THE DATA SET IS GLOBAL OR POLAR'
  write (*,*) '1 IF THE DATA SET DOES NOT INCLUDE ALL LONGITUDES'
  read (*,*) global
c
  if (prime .eq. 1) then
    write (*,*) 'NOTE: FILE Y WILL HAVE THE FIRST PASS MOVED'
    write (*,*) 'TO THE BOTTOM OF THE FILE'
    write (*,*) ''
    if (global .eq. 1) then
      write (*,*) 'AND THE FIRST PASS WILL NOT BE INCLUDED IN'
      write (*,*) 'THE PROCESSING. FILE X WILL HAVE THE LAST'
      write (*,*) 'PASS REMOVED AND THIS PASS WILL NOT BE INCLUDED'
      write (*,*) 'IN THE PROCESSING'
    endif
  endif
c
  write (*,*) 'INPUT FILE X OF LAT-LONG-RAD DATA'
  read (*,9990) filename
  9990 format(a80)
  open (10, file=filename, status='old', form='unformatted')
  write (*,*) 'INPUT FILE X OF MAGNETIC VARIABLES'
  read (*,9990) filename
  open (11, file=filename, status='old', form='unformatted')
  write (*,*) 'INPUT FILE Y OF LAT-LONG-RAD DATA'
  read (*,9990) filename
  open (12, file=filename, status='old', form='unformatted')
  write (*,*) 'INPUT FILE Y OF MAGNETIC VARIABLES'
  read (*,9990) filename
  open (13, file=filename, status='old', form='unformatted')
c
  if (ifilenum .eq. 1) then
    write (*,*) 'OUTPUT FILE OF TRUNCATED LAT-LONG-RAD-ANOM DATA'
    write (*,*) 'AND -----NO HEADERS TO BE WRITTEN-----'
    read (*,9990) filename
    open (20, file=filename, form='formatted')
    write (*,*) 'OUTPUT FILE OF LAT-LON TO BE RUN IN TPLOT'
    read (*,9990) filename
    open (21, file=filename, form='unformatted')
  c
  elseif (ifilenum .eq. 2) then
    write (*,*) 'OUTPUT FILE X OF LAT-LON-RAD'
    read (*,9990) filename
    open (30, file=filename, form='unformatted')

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```

write (*,*) 'OUTPUT FILE X OF VARIABLE'
read (*,9990) filename
open (31, file=filename, form='unformatted')
write (*,*) 'OUTPUT FILE Y OF LAT-LON-RAD'
read (*,9990) filename
open (32, file=filename, form='unformatted')
write (*,*) 'OUTPUT FILE Y OF VARIABLE'
read (*,9990) filename
open (33, file=filename, form='unformatted')
endif
c
write (*,*) 'OUTPUT FILE OF STATISTICS'
read (*,9990) filename
open (25, file=filename,form='formatted')
c
write (*,*) '0 IF THESE ARE DUSK DATA SETS'
write (*,*) '1 IF THESE ARE DAWN DATA SETS'
read (*,*) dndk
if (ifilename .eq. 1) then
write (*,*) '0 DO NOT REMOVE THE MEAN FROM THE AVERAGED DATASET'
write (*,*) '1 REMOVE THE MEAN'
read (*,*) choice
endif
write (*,*) '0 IF ALL PASSES ARE WANTED'
write (*,*) '1 TO REMOVE THE PASSES THAT ARE NOT WANTED'
read (*,*) nocnt
if (nocnt .eq. 1) then
    write (*,*) 'INPUT FILE OF PASSES NOT WANTED'
    read (*,9990) filename
    open (14, file=filename,form='formatted',status='old')
    do 5 i=1,4000
        read (14,*,end=6) nowant(i)
5      continue
      continue
      nocnt=i-1
    endif
    if (prime .eq. 1) then
        write (*,*) '1 FOR A LATITUDE GAP FINDER'
        write (*,*) '2 FOR A MINIMUM OBSERVATION GAP FINDER'
        read (*,*) type
    endif
    write (*,*) 'AND FINALLY! MINIMUM NUMBER OBSERVATIONS PER PASS'
    read (*,*) minobs
c
    if (prime .eq. 1) then
        write (*,*) '-----'
        write (*,*) 'running through dataset to find passes that',
        >           ' do not overlap'
c----- findgap locates adjacent
c----- passes that do not overlap
c----- call findgap (global,dndk,minobs,type)
        write (*,*) 'done with run through'
        write (*,*) '-----'
    endif
c
    write (25,*) 'XPASS YPASS CCD      CCY      XVAR      YVAR ',
    >           ' COVARXY  XSTDEV  YSTDEV'
    write (25,*) '           XMEAN  YMEAN   XSLOPE  YSLOPE',
    >           ' XINTCPT  YINTCPT'
c
    paircnt=0
    paircntl=0
    tcount=0
    strcnt=0
    totobs=0
    noc=0
    crosscnt=0
    passrem=0
c
10   continue
    read (10,end=999) x3row,x3col,zero,x3mean,x3pass,eight
    do 15 i=1,x3row
        read (10) (x3data(i,ii),ii=1,x3col)
15   continue
    read (11) xrow,xcol,zero,xmean,xpassno,eight
    do 25 i=1,xrow
        read (11) xldata(i)
25   continue
    read (12,end=150) y3row,y3col,zero,y3mean,y3pass,eight
    do 35 i=1,y3row
        read (12) (y3data(i,ii),ii=1,y3col)
35   continue
    read (13) yrow,ycol,zero,ymean,ypassno,eight
    do 45 i=1,yrow
        read (13) yldata(i)
45   continue
c
    strcnt=strcnt+1
c----- this if statement offsets the passes

```

```

c           and saves the offset for the end
c     if (strcnt .eq. 1 .and. prime .eq. 1) then
      do 50 i=1,y3row
        do 55 ii=1,y3col
          savey3(i,ii)=y3data(i,ii)
55      continue
          savey1(i)=y1data(i)
50      continue
      y3row=y3row
      syrow=yrow
      sy3col=y3col
      sycol=ycol
      sy3mean=y3mean
      symean=ymean
      sy3pass=y3pass
      sypassno=ypassno
      go to 30
    endif
c     go to 190
c
150  continue
    if (global .eq. 1) go to 999
    do 160 i=1,sy3row
      do 165 ii=1,sy3col
        y3data(i,ii)=savey3(i,ii)
165  continue
        y1data(i)=savey1(i)
160  continue
      y3row=sy3row
      yrow=syrow
      y3col=sy3col
      ycol=sycol
      y3mean=sy3mean
      ymean=symean
      y3pass=sy3pass
      ypassno=sypassno
c
190  continue
c
    if (xrow.ne.x3row .or. xpassno.ne.x3pass .or.
>     yrow.ne.y3row .or. ypassno.ne.y3pass) then
      write (*,*) 'WACKO, TRA-LA-LA, JOLLY-GOOD, NO MATCH BETWEEN'
      write (*,*) 'ROWS OR PASSNOS X= ',xrow,x3row,xpassno,x3pass
      write (*,*) 'Y= ',yrow,y3row,ypassno,y3pass
      go to 999
    elseif (xrow .lt. minobs .or. yrow .lt. minobs) then
      write(*,*) 'FILE X PASS',xpassno,' REMOVED: OBSERVATIONS-',xrow
      write(*,*) 'FILE Y PASS',ypassno,' REMOVED: OBSERVATIONS-',yrow
      passrem=passrem+1
      go to 10
    endif
    do 195 i=1,nocnt
      if (nowant(i).eq.xpassno .or. nowant(i).eq.ypassno) then
        write (*,*) 'FILE X PASS',xpassno,' REMOVED NOT WANTED'
        write (*,*) 'FILE Y PASS',ypassno,' REMOVED NOT WANTED'
        passrem=passrem+1
        go to 10
      endif
195  continue
c     call truncate (xrow,yrow,dndk,nobs,paircnt1,minobs)
c     call statistics (nobs,xpassno,ypassno,xamean,ybmean)
c
    if (ifilenum .eq. 1) call average (nobs,choice,prime,crosscnt)
c
    if (ifilenum .eq. 2) then
      if (xpassno .ne. ypassno) then
        write (*,*) xpassno,ypassno,' no match pass numbers'
        stop 444
      endif
      ithree=3
      ione=1
      xxavg=0.0
      ieight=8888
      izero=0
      write (30) nobs,ithree,zero,xxavg,xpassno,ieight
      write (31) nobs,ione,zero,xxavg,xpassno,ieight
      write (32) nobs,ithree,zero,xxavg,ypassno,ieight
      write (33) nobs,ione,zero,xxavg,ypassno,ieight
      do j=1,nobs
        if (xadata(j,3) .gt. 180.0) xadata(j,3)=xadata(j,3)-360.0
        write (30) xadata(j,1),(xadata(j,1),i=3,4)
        write (31) xadata(j,2)
        if (ybdata(j,3) .gt. 180.0) ybdata(j,3)=ybdata(j,3)-360.0
        write (32) ybdata(j,1),(ybdata(j,1),i=3,4)
        write (33) ybdata(j,2)
      enddo
      go to 300

```

```

        endif
c-----write out the truncated lengths passes
c
        if (prime .eq. 1) then
          do 200 j=1,nobs
            if (xadata(j,3) .gt. 180.0) xadata(j,3)=xadata(j,3)-360.0
            write (20,*) xadata(j,1),(xadata(j,i),i=3,4),avgdata(j,4)
200      continue
          do 205 j=1,nobs-1
            if (xadata(j,3) .lt. xadata(j+1,3)) then
              crosscnt=crosscnt+
              go to 207
            endif
205      continue
207      continue
        elseif (prime .eq. 2) then
          do 220 j=1,nobs
            if (avgdata(j,2).gt.180.0) avgdata(j,2)=avgdata(j,2)-360.0
            write (20,*) (avgdata(j,k),k=1,4)
220      continue
        endif
c----- write out the trace of the pass for plotting
c----- in tplot
c
        call track (nobs,noc,prime)
        WRITE (21) NOC,NObs, (X(J),Y(J),J=1,NObs)
c
300  continue
        if (paircnt1 .gt. 0) tcount=tcount+
        paircnt=paircnt+paircnt1
        totobs=totobs+nobs
c
        go to 10
c
999  continue
        write (*,*) 'corrected',paircnt,' pairs of latitudes in'
        write (*,*) tcount,' passes to beginning lengths'
        write (*,*) 'total passes read = ',strcnt
        write (*,*) 'removed',passrem,' passes from the file'
        write (*,*) 'total observations in the written dataset = ',totobs
        write (*,*) 'study area includes',crosscnt,' pairs of',
        >           ' longitudes that cross -180.0 180.0'
        close (10)
        close (11)
        close (12)
        close (13)
        close (20)
        close (21)
        close (25)
        close (30)
        close (31)
        close (32)
        close (33)
        stop
      end

c
c
      subroutine truncate (xrow,yrow,dndk,minrow,stocount,minobs)
      integer xrow,yrow,stocount,rowii,rowinc,minrow,
      >           dndk,minobs
      real xdata(400,4),ydata(400,4),
      >           x3data(400,3),xldata(400),y3data(400,3),yldata(400),
      >           adata,bdata,diffab,abss,xadata(400,4),ybdata(400,4)
      common /trunstat/ xadata(400,4),ybdata(400,4)
      common x3data(400,3),xldata(400),y3data(400,3),yldata(400)
c----- subroutine description
c
c      truncate locates the overlapping segment between two
c      adjacent passes and stores that segment in the
c      appropriate arrays
c
      do 70 j=1,xrow
        xdata(j,1)=x3data(j,1)
        xdata(j,2)=xldata(j)
        xdata(j,3)=x3data(j,2)
        xdata(j,4)=x3data(j,3)
70    continue
      do 75 j=1,yrow
        ydata(j,1)=y3data(j,1)
        ydata(j,2)=yldata(j)
        ydata(j,3)=y3data(j,2)
        ydata(j,4)=y3data(j,3)
75    continue
c
80    continue
      stocount=0
      jj=1
      rowii=xrow

```

```

rowinc=yrow
c-----loops from 90 to 200 increment through the
c-----two input passes and truncate the lengths
c-----to the same length
90  continue
    adata=xdata(jj,1)
    bdata=ydata(jj,1)
    diffab=adata-bdata
    abss=abs(diffab)
    if (rowii .eq. 0 .or. rowinc .eq. 0) then
        write (*,*) 'xrows (ii) =',rowii,' yrows (inc) =',rowinc
        write (*,*) 'xrow =',xrow,' yrow =',yrow
        stop
    endif
    minrow=min(rowii, rowinc)
c-----if pass a (ii) matches pass b (inc) at
c-----beginning length then write to xdata and
c-----ydata and race to main program
    if (abss .lt. 0.33) then
        do 110 ll=1,minrow
            do 110 kk=1,4
                xadata(ll,kk)=xdata(ll,kk)
                ybdata(ll,kk)=ydata(ll,kk)
110    continue
        return
    endif
c-----if pass a no matcha the b data then find new
c-----a or b depending on whether or not ascending
c-----or descending order of independent variable
    if (abss .ge. 0.33) then
        stocount=stocount+1
c-----if this is a dusk pass then will count from
c------90.0 lat degrees toward the equator
        if (dndk .eq. 0) then
            if (xdata(jj,1) .gt. ydata(jj,1)) then
                rowinc=rowinc-1
                do 130 mm=1, rowinc
                    do 130 kk=1,4
                        ydata(mm,kk)=ydata(mm+1,kk)
130    continue
            elseif (xdata(jj,1) .lt. ydata(jj,1)) then
                rowii=rowii-1
                do 150 nn=1, rowii
                    do 150 kk=1,4
                        xadata(nn,kk)=xdata(nn+1,kk)
150    continue
        endif
c-----if this is a dawn pass then will count from
c-----the equator toward the south pole
c-----that is decreasing independent variable
        elseif (dndk .eq. 1) then
            if (xdata(jj,1) .lt. ydata(jj,1)) then
                rowinc=rowinc-1
                do 160 mm=1, rowinc
                    do 160 kk=1,4
                        ydata(mm,kk)=ydata(mm+1,kk)
160    continue
            elseif (xdata(jj,1) .gt. ydata(jj,1)) then
                rowii=rowii-1
                do 170 nn=1, rowii
                    do 170 kk=1,4
                        xadata(nn,kk)=xdata(nn+1,kk)
170    continue
        endif
    endif
c-----go to 90
c-----end
c-----subroutine statistics (minrow,xpassno,ypassno,xamean,ybmean)
c-----integer minrow,nobs,xpassno,ypassno
c-----real xadata(400,4),ybdata(400,4),nobs
c-----common /trunstat/ xadata(400,4),ybdata(400,4)
c-----from 200 to write statement of variables is
c-----the statistical calculations using two
c-----references:
c-----1) Davis, Statistics and Data Analysis in
c-----Geology, 2nd ed., 1986 pp. 41
c-----2) Young, Statistical Treatment of Experimental
c-----Data, 1962, McGraw Hill, 115-132
c-----loops that sum x, x**2, y, y**2 and xy
c-----and calculate new truncate means
nobs=minrow
nobss=float(nobs)

```

```

xsum=0.0
xsumsqr=0.0
ysum=0.0
ysumsqr=0.0
sumxy=0.0
do 240 j=1,nobs
  xsum=xsum+xadata(j,2)
  xsumsqr=xsumsqr+(xadata(j,2))**2
  ysum=ysum+ybdata(j,2)
  ysumsqr=ysumsqr+(ybdata(j,2))**2
  sumxy=sumxy+(xadata(j,2)*ybdata(j,2))
240  continue
c   write (*,*) xsum,ysum,xsumsqr,ysumsqr,sumxy
c-----find corrected sum of products, covariance
c   and corrected sum of squares (x) (y)
c
c   xamean=xsum/nobss
c   ybmean=ysum/nobss
c   sumprod=sumxy-((xsum*ysum)/nobss)
c   covarxy=sumprod/(nobss-1.0)
c   xcsumsqr=xsumsqr-((xsum**2)/nobss)
c   ycsumsqr=ysumsqr-((ysum**2)/nobss)
c
c-----find variance, standard deviation for x and y
c
c   xvar=xcsumsqr/(nobss-1.0)
c   yvar=ycsumsqr/(nobss-1.0)
c   xstdev=sqrt(xvar)
c   ystdev=sqrt(yvar)
c-----find correlation coefficient by Davis method
c   corrDxy=covarxy/(xstdev*ystdev)
c-----find slopes, intercepts and correlation
c   coefficient by Young method
c
c   xslope=((nobss*sumxy)-(xsum*ysum))/((nobss*xsumsqr)-xsum**2)
c   yslope=((nobss*sumxy)-(xsum*ysum))/((nobss*ysumsqr)-ysum**2)
c   xintcpt=((ysum*xsumsqr)-(sumxy*xsum))/((nobss*xsumsqr)-xsum**2)
c   yintcpt=((xsum*ysumsqr)-(sumxy*ysum))/((nobss*ysumsqr)-ysum**2)
c   corrXxy=sqrt(xslope*yslope)
c
c-----write out this mess for individual pass and
c   overlapping lengths of passes
c
c   write (25,9992)xpassno,ypassno,xvar,yvar,xstdev,ystdev,
c   >           xamean,ybmean
9992 format ('FOR OVERLAPPING LENGTHS  X=',15.15,/,'
  'X VARIANCE=',f9.3,' Y VARIANCE=',f9.3,' X STDEV=',
  >           f9.3,' Y STDEV=',f9.3,' XMEAN=',f9.3,' YMEAN=',f9.3)
c   write (25,9993) covarxy,corrDxy
9993 format ('COVARIANCE XY=',f9.3,' Davis CORRELATION COEF=',f9.3)
c   write (25,9994) xslope,xintcpt,yslope,yintcpt,corrXxy
9994 format ('X SLOPE=',f9.3,' X INTERCEPT=',f9.3,' Y SLOPE=',
  >           f9.3,' Y INTERCEPT=',f9.3,' Young CORRELATION COEF=',
  >           f9.3,/)
c   write (25,9995) xpassno,ypassno,corrDxy,corrXxy,xvar,yvar,
  >           covarxy,xstdev,ystdev
9995 format (215,7(f10.4))
  write (25,9996) xamean,ybmean,xslope,yslope,xintcpt,yintcpt
9996 format (10x,6(f10.4))
  return
  end
c
c
c
c   subroutine average (nobs,choice,prime,crosscnt)
  real xadata(400,4),ybdata(400,4),avgdatmean,avgdatsum,
  >           avgdata(400,4),nobss
  integer nobs,choice,prime,crosscnt
  common /trunstat/ xadata(400,4),ybdata(400,4)
  common /aver/ avgdata(400,4)
c
c----- subroutine description
c   average calculates the average magnetic value of the
c   input passes.  it will also find the average position
c   of the input passes if so directed.
c
  avgdatsum=0.0
  nobss=real(nobs)
c
  if (prime .eq. 2) then
    do 100 i=1,nobs
      avgdata(i,1)=((xadata(i,1)+ybdata(i,1))/2.0)
      avgdata(i,2)=((xadata(i,3)+ybdata(i,3))/2.0)
      addxy = abs(xadata(i,3)) + abs(ybdata(i,3))
      if (addxy .gt. 270.0) then
        crosscnt=crosscnt+1
        if (ybdata(i,3).gt.0.0 .and. xadata(i,3).lt.0.0) then
          xadata(i,3) = xadata(i,3) + 360.0
        elseif (ybdata(i,3).lt.0.0 .and. xadata(i,3).gt.0.0) then

```

```

        ybdata(i,3) = ybdata(i,3) + 360.0
    endif
    avgdata(i,2)=((xadata(i,3)+ybdata(i,3))/2.0)
    if (avgdata(i,2) .gt. 180.0)
        avgdata(i,2)=avgdata(i,2)-360.0
    endif
    avgdata(i,3)=((xadata(i,4)+ybdata(i,4))/2.0)
    avgdata(i,4)=((xadata(i,2)+ybdata(i,2))/2.0)
    avgdatsum=avgdatsum+avgdata(i,4)
100    continue
    avgdatmean=avgdatsum/nobs
    if (choice .eq. 1) then
        do 150 i=1,nobs
            avgdata(i,4)=avgdata(i,4)-avgdatmean
150    continue
    endif
c
    elseif (prime .eq. 1) then
        do 200 i=1,nobs
            avgdata(i,4)=((xadata(i,2)+ybdata(i,2))/2.0)
            avgdatsum=avgdatsum+avgdata(i,4)
200    continue
    avgdatmean=avgdatsum/nobs
    if (choice .eq. 1) then
        do 250 i=1,nobs
            avgdata(i,4)=avgdata(i,4)-avgdatmean
250    continue
    endif
    endif
c
    return
end
c
c
c
    subroutine track (nop,noc,prime)
    integer nop,noc,prime
    real rafac,avgdata(400,4),x(400),y(400),xadata(400,4),
    > ybdata(400,4)
    common /aver/ avgdata(400,4)
    common /tpplot/ x(400),y(400)
    common /trunstat/ xadata(400,4),ybdata(400,4)
c
c----- subroutine description
c
c      track finds the lat and long coordinates of the observations
c      along an orbit.  these coordinates can be plotted as the
c      trace of the pass along the earth.
c      NOTE: lat and long are changed to radians for the plotting
c      package that i use.
c
    RADFAC=0.017453293
    noc=noc+1
    if (prime .eq. 2) then
        DO 200 J=1,NOP
            x(j)=90.0-avgdata(j,1)
            y(j)=avgdata(j,2)
            if (y(j) .lt. 0.) y(j)=y(j)+360.
            X(j)=X(j)*RADFAC
            Y(j)=Y(j)*RADFAC
200    CONTINUE
    elseif (prime .eq. 1) then
        do 300 j=1,nop
            x(j) = 90.0 - xadata(j,1)
            y(j) = xadata(j,3)
            if (y(j) .lt. 0.0) y(j) = y(j) + 360.0
            x(j) = x(j) * rafac
            y(j) = y(j) * rafac
300    continue
    endif
c
    return
end
c
c
c
    subroutine findgap (global,dndk,minobs,type)
    integer zero,eight,strtotpass,x3row,x3col,x3pass,
    > y3row,y3col,y3pass,cnt,type,strmincnt,
    > dndk,nowant(4000),nocnt,mincnt,
    > minobs,totpass,global,
    > noppass,strnocnt,allcnt,strallcnt
    real y3data(400,3),y3mean,abss,allxdat(4000,4),
    > allydat(4000,4),x3mean,x3data(400,3),stryone(4)
    common /hope/ nowant(4000),nocnt
c
c----- subroutine description
c
c      findgap locates the overlapping segment in each of the
c      two adjacent passes.  this is done by looking at the
c      first and last latitudes in each pass and comparing
c      the values.  if there are two passes that do not have
c      overlapping segments, then one of the two passes

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c      is removed.
c      NOTE: the difference between a latitude gap finder and
c      a minimum observation gap finder is: a latitude
c      finder allows extremely short passes to be worked
c      with in the processing whereas a minimum observation
c      gap finder removes all short passes. the trade off
c      occurs because a minimum observation finder actually
c      allows a higher number of observations to be worked
c      with in collocation. therefore a minobs gap finder
c      is usually best. experiment to see what u like.

c      totpass=0
c      allcnt=0
c      strnocnt=nocnt

c      10  continue
c          read (10,end=30) x3row,x3col,zero,x3mean,x3pass,eight
c          do 15 i=1,x3row
c              read (10) (x3data(i,ii),ii=1,x3col)
c      15  continue
c          totpass=totpass+1
c          if (x3row .lt. minobs) then
c              nowant(nocnt+1)=x3pass
c              nocnt=nocnt+1
c          endif
c          allcnt=allcnt+1
c          allxdat(allcnt,1)=real(x3pass)
c          allxdat(allcnt,2)=real(x3row)
c          allxdat(allcnt,3)=x3data(1,1)
c          allxdat(allcnt,4)=x3data(x3row,1)
c          go to 10

c      30  continue
c          strtotpass=totpass
c          strallcnt=allcnt
c          totpass=0
c          allcnt=0
c      31  read (12,end=50) y3row,y3col,zero,y3mean,y3pass,eight
c          do 35 i=1,y3row
c              read (12) (y3data(i,ii),ii=1,y3col)
c      35  continue
c          totpass=totpass+1
c          if (y3row .lt. minobs) then
c              nowant(nocnt+1)=y3pass
c              nocnt=nocnt+1
c          endif
c          allcnt=allcnt+1
c          allydat(allcnt,1)=real(y3pass)
c          allydat(allcnt,2)=real(y3row)
c          allydat(allcnt,3)=y3data(1,1)
c          allydat(allcnt,4)=y3data(y3row,1)
c          go to 31

c      50  continue
c          if (totpass.ne.strtotpass .or. allcnt.ne.strallcnt) then
c              write (*,*) 'FILES DO NOT HAVE THE SAME NUMBER OF PASSES'
c              write (*,*) 'FILE X PASS COUNT=',strtotpass,strallcnt
c              write (*,*) 'FILE Y PASS COUNT=',totpass,allcnt
c              stop
c          endif
c
c          do 52 ii=1,4
c              stryone(ii)=allydat(1,ii)
c      52  continue
c          do 55 i=1,allcnt-1
c              do 55 ii=1,4
c                  allydat(i,ii)=allydat(i+1,ii)
c      55  continue
c          do 57 ii=1,4
c              allydat(allcnt,ii)=stryone(ii)
c      57  continue
c          if (global .eq. 1) allcnt=allcnt-1
c
c          if (type .eq. 2) go to 400
c
c----- work a latitude gap finder
c      70  continue
c          cnt=1
c
c      100 continue
c          if (allxdat(cnt,1) .ne. allydat(cnt,1)) then
c              write (*,*) 'PASSES DO NOT MATCH FOR A-east A-west'
c              write (*,*) 'REVERSE THE ORDER OF INPUT FILES AND RERUN'
c              stop
c          endif
c          if (nocnt .eq. 0) go to 140
c          do 110 i=1,nocnt
c              if (int(allxdat(cnt,1)) .eq. nowant(i)) then
c                  if (cnt+1 .gt. allcnt) go to 190
c                  do 105 jj=cnt,allcnt-1

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```

        do 105 jj=1,4
          allxdat(jj,j)=allxdat(jj+1,j)
          allydat(jj,j)=allydat(jj+1,j)
105      continue
          allcnt=allcnt-1
        endif
110    continue
140    continue
      abss=abs(allxdat(cnt,3)-allydat(cnt,3))
      if (abss .lt. 0.33) go to 190
      if (abss .ge. 0.33) then
        nopass=int(allxdat(cnt,1))
c-----if this is a dusk pass then will count from
c      -90.0 lat degrees toward the equator
      if (dndk .eq. 0) then
        if (allxdat(cnt,3) .gt. allydat(cnt,3)) then
          if (allxdat(cnt,3) .gt. allydat(cnt,4)) then
            nocnt=nocnt+1
            nowant(nocnt)=nopass
          endif
        elseif (allxdat(cnt,3) .lt. allydat(cnt,3)) then
          if (allxdat(cnt,4) .lt. allydat(cnt,3)) then
            nocnt=nocnt+1
            nowant(nocnt)=nopass
          endif
        endif
c-----if this is a dawn pass then will count from
c      the equator toward the south pole
c      that is decreasing independent variable
      elseif (dndk .eq. 1) then
        if (allxdat(cnt,3) .lt. allydat(cnt,3)) then
          if (allxdat(cnt,3) .lt. allydat(cnt,4)) then
            nocnt=nocnt+1
            nowant(nocnt)=nopass
          endif
        elseif (allxdat(cnt,3) .gt. allydat(cnt,3)) then
          if (allxdat(cnt,4) .gt. allydat(cnt,3)) then
            nocnt=nocnt+1
            nowant(nocnt)=nopass
          endif
        endif
      endif
      endif
190    continue
      cnt=cnt+1
      if (cnt .gt. allcnt) go to 200
      go to 100
c
200    continue
      if (nocnt .eq. strnocnt) go to 999
      if (strnocnt .lt. nocnt) then
        strnocnt=nocnt
        go to 70
      endif
c
c----- work a minimum observations gap finder
400    continue
      mincnt=0
      strmincnt=mincnt
c
470    continue
      cnt=1
c
500    continue
      if (allxdat(cnt,1) .ne. allydat(cnt,1)) then
        write (*,*) 'PASSES DO NOT MATCH FOR A-east A-west'
        write (*,*) 'REVERSE THE ORDER OF INPUT FILES AND RERUN'
        stop
      endif
      if (int(allxdat(cnt,2)) .lt. minobs .or.
>        int(allydat(cnt,2)) .lt. minobs) then
        if (cnt+1 .gt. allcnt) go to 590
        do 505 jj=cnt,allcnt-1
          do 505 jj=1,4
            allxdat(jj,j)=allxdat(jj+1,j)
            allydat(jj,j)=allydat(jj+1,j)
505      continue
          allcnt=allcnt-1
        go to 500
      endif
510    continue
540    continue
      abss=abs(allxdat(cnt,3)-allydat(cnt,3))
      if (abss .lt. 0.33) go to 590
      if (abss .ge. 0.33) then
        xrow=int(allxdat(cnt,2))
        yrow=int(allydat(cnt,2))
        minxyrow=min(xrow,yrow)

```

```

mincnt2=mincnt
c-----if this is a dusk pass then will count from
c------90.0 lat degrees toward the equator
c      if (dndk .eq. 0) then
c          if (allxdat(cnt,3) .gt. allydat(cnt,3)) then
c              if (allxdat(cnt,3) .gt. allydat(cnt,4)) mincnt=mincnt+1
c              elseif (allxdat(cnt,3) .lt. allydat(cnt,3)) then
c                  if (allxdat(cnt,4) .lt. allydat(cnt,3)) mincnt=mincnt+1
c                  endif
c-----if this is a dawn pass then will count from
c-----the equator toward the south pole
c-----that is decreasing independent variable
c      elseif (dndk .eq. 1) then
c          if (allxdat(cnt,3) .lt. allydat(cnt,3)) then
c              if (allxdat(cnt,3) .lt. allydat(cnt,4)) mincnt=mincnt+1
c              elseif (allxdat(cnt,3) .gt. allydat(cnt,3)) then
c                  if (allxdat(cnt,4) .gt. allydat(cnt,3)) mincnt=mincnt+1
c                  endif
c          endif
c          if (mincnt .gt. mincnt2) minobs=minxyrow+1
c      endif
c
c 590  continue
c      cnt=cnt+1
c      if (cnt .gt. allcnt) go to 600
c      go to 500
c
c 600  continue
c      if (mincnt .eq. strmincnt) go to 999
c      if (strmincnt .lt. mincnt) then
c          strmincnt=mincnt
c          go to 470
c      endif
c
c 999  continue
c      write (*,*) 'total passes read = ',totpass
c      if (nocnt .gt. 0) then
c          write (*,*) 'will remove the following passes from processing'
c          do 1010 i=1,nocnt
c              write (*,*) nowant(i),i
c
c 1010  continue
c      endif
c      if (type .eq. 2) write (*,*) 'new minimum observation cutoff',
c      >           ' is ',minobs
c      rewind (10)
c      rewind (12)
c
c      return
c      end

```

B-85

θ-85

00 1980. MAGSAT12/83 FIELD MODEL

2	1	-29986.5977	0	26.5047	0
2	2	-1956.0098	5603.8984	11.9441	-15.9892
3	1	-1996.6699	0	-17.7715	0
3	2	3027.3098	-2129.2998	3.5560	-14.9880
3	3	1662.6899	-199.7370	03.1459	-24.1879
4	1	1281.4099	0	01.2007	0
4	2	-2180.5198	-335.5408	-3.6188	2.2614
4	3	1250.8599	270.8979	-1.1017	2.5249
4	4	832.8589	-252.2290	1.8474	-4.1066
5	1	937.6270	0	-.6511	0
5	2	782.2798	212.1880	-2.0523	2.9464
5	3	397.8979	-256.6948	-5.8275	02.0422
5	4	-418.9170	52.8622	-2.4301	1.9796
5	5	198.8960	-297.1729	-2.7610	-2.4318
6	1	-217.8750	0	.0000	0
6	2	357.2400	45.9779	-0.0000	1.4379
6	3	261.0259	149.8220	-1.2862	0.4783
6	4	-74.2543	-150.6240	-4.1370	-0.9792
6	5	-161.9080	-77.7266	-1.3131	0.5830
6	6	-48.0216	92.1005	00.0000	.1310
7	1	47.9521	0	1.5744	0
7	2	65.5112	-14.7623	0.3746	00.4169
7	3	41.9219	93.0835	.9571	-0.7149
7	4	-192.1090	70.5787	1.2512	0.0000
7	5	3.5873	-43.0699	.6488	-0.4089
7	6	13.8212	-2.2228	.8309	.3552
7	7	-107.7240	17.2125	01.5749	1.5578
8	1	71.9145	0	1.3718	0
8	2	-59.2225	-82.4974	-0.7318	-0.8626
8	3	1.6950	-27.4258	.3371	.7545
8	4	20.7407	-4.9118	.0000	.3567
8	5	-12.4245	16.2844	0.7764	0.1974
8	6	.6345	17.7860	-0.0000	0.3800
8	7	10.5919	-23.0138	0.0000	0.4037
8	8	-1.6744	-9.6949	1.7731	0.0000
9	1	18.4829	0	0.7492	0
9	2	6.5464	6.8482	0	-0.6295
9	3	-.4431	-17.7074	0.3060	
9	4	-10.9846	4.2139		
9	5	-6.9316	-22.1996	-.8890	
9	6	4.2292	9.1278	.2806	.6764
9	7	2.7169	16.0818		-.8512
9	8	6.0254	-13.2103		
9	9	-1.3743	-14.5602	-2.2246	-1.7360
10	1	5.2888	0	-.2980	
10	2	10.3522	-20.8464		.4655
10	3	1.3838	15.5210	.4694	
10	4	-12.3472	8.7402		.8824
10	5	9.4401	-5.3002		.5640
10	6	-3.4208	-6.3179	-.0717	
10	7	-1.1873	9.0043		
10	8	6.7100	9.6459		
10	9	1.4932	-5.9579	-.4223	.3562
10	10	-4.9898	1.9550	-1.0560	2.0960
11	1	-3.4630	0	.8585	
11	2	-4.0062	1.2249		-.4876
11	3	2.2272	.5099	-.4740	
11	4	-5.4032	2.6612	-.2979	-.4653
11	5	-1.9878	5.7745	.7246	-.9477
11	6	4.5775	-4.2379		-.6276
11	7	3.1480	-.4134		
11	8	.9039	-1.3354	-.6724	
11	9	1.9700	3.5658	1.2551	
11	10	2.8069	-.4729	.1466	-.2740
11	11	-.2741	-6.1331	-.5215	
12	1	2.4795	0		
12	2	-1.1335	.6132		
12	3	-1.6582	1.7210		
12	4	2.1526	-1.3117		
12	5	.0610	-3.1316		
12	6	-.6072	.7970		
12	7	-.3238	-.0409		
12	8	1.6151	-2.4801		
12	9	1.7163	-.3808		
12	10	-.7606	-1.6667		
12	11	2.0084	-1.5290		
12	12	3.4451	0.7629		
13	1	-1.7069	0		
13	2	-.1409	.2182		
13	3	-.2764	.7604		
13	4	-.2045	2.5462		
13	5	.6790	-1.4956		
13	6	.6367	.3952		
13	7	-.4485	.2423		
13	8	-.1787	-.2355		
13	9	.2656	.0192		
13	10	-.4602	-.0133		
13	11	0.1407	-1.2097		
13	12	.5953	.3708		

13 13	-.1378	.4564
14 1	-.2049	0
14 2	-.5967	-.4816
14 3	.3725	.3039
14 4	-.8791	1.4826
14 5	-.1829	-.2216
14 6	1.1048	-.4758
14 7	-.4404	-.2088
14 8	.3847	.7995
14 9	-.4823	.0535
14 10	.1867	.8530
14 11	-.1106	.0633
14 12	.3455	-.1350
14 13	-.0851	0.2500
14 14	.3797	-.3348
-1 0	0.	0.

APPENDIX C: MAP PROCESSING

PROGRAMS

collocation.f
fourier2d.f
avgdifres.f
sqrmap.f
inversion.f

DATA FILE

rmagcov


```

program collocation
*****
C THIS PROGRAM READS A FILE OF IRREGULARLY DISTRIBUTED
C DATA POINTS (LATITUDE, LONGITUDE, ELEVATION, ANOMALY
C VALUE) AND PREDICTS THE GRIDDED ANOMALIES ON A GRID OF
C SPECIFIED DENSITY. THE ANOMALY ESTIMATE FOR EACH GRID
C LOCATION IS OBTAINED FROM NCPP NEAREST SAMPLE POINTS
C USING A LOCAL COVARIANCE MODEL. THE PROCEDURE KNOWN AS
C LEAST-SQUARES COLLOCATION INVOKES THE FOLLOWING STEPS:
C
C 1. REMOVE THE MEAN OF THE ANOMALIES IN THE PREDICTION
C    AREA TO OBTAIN RESIDUALS CENTERED AROUND MEAN
C 2. SEARCH FOR THE NCPP CLOSEST DATA POINTS TO THE GRID
C    LOCATION AND STORE THEM IN VECTOR (M1)
C 3. FORM THE COVARIANCE MATRIX (COVM) OF THE NCPP DATA
C    POINTS
C 4. ADD THE ERROR VARIANCE OF THE DATA POINTS TO THE
C    DIAGONAL OF 'COVM' MATRIX, TO FORM THE FINAL 'COVM'
C    MATRIX
C 5. INVERT 'COVM' MATRIX AND STORE THE RESULT AGAIN IN
C    'COVM'
C 6. FORM THE CROSS-COVARIANCE VECTOR (T1) BETWEEN THE
C    GRID VALUE TO BE PREDICTED AND THE NCPP DATA POINTS
C 7. BY LEAST SQUARES COLLOCATION, THE ANOMALY ESTIMATE
C    IS GIVEN AS:
C
C    TP=T1*COVM*M1
C
C    AND THE STANDARD ERROR OF PREDICTION IS GIVEN BY,
C
C    SEP=DSQRT(VAR-T1*COVM*T1)
C
C    VAR...COVARIANCE AT ZERO SEPARATION (I.E. VARIANCE)
C
C
C    THE ABOVE EQUATIONS INVOLVE THE MATRIX OPERATIONS.
C
*****
C
C PRELIMINARY SOFTWARE EXPLICITLY DEVELOPED FOR GRAVITY
C PREDICTION OVER A SPHERICAL SURFACE WAS MADE AVAILABLE
C BY GEODETIC SCIENCE DEPARTMENT AT THE OHIO STATE
C UNIVERSITY. IT WAS MODIFIED FOR NASA MAGNETIC SATELLITE
C APPLICATION FOR 3-D PREDICTION AND THEREBY ALTITUDE
C NORMALIZATION.
C
C MODIFICATIONS BY: HARISH K. GOYAL
C DEPT. OF GEOL & MIN, OSU
C TEL. 422-1434, CAMPUS
C MAR, 1986
C
C 1. LATITUDES ARE CHANGED TO CO-LATITUDES TO COMPLY
C    WITH SPHERICAL COORDINATES.
C 2. SEPARATION DISTANCES ARE THE RADIAL VECTORS TO
C    ACCOUNT FOR THREE DIMENSIONAL VARIABILITY
C 3. COVARIANCES ARE AUTOMATICALLY SCALED IN THE
C    PROGRAM
C
C further modifications 11 may 90
C these modifications are all lower case letters
C
C well'p just a few more modifications on 8 sep 90
C these changes are: 1) removal of unnecessary arrays
C 2) changing all arrays to real*4 and not real*8
C 3) keeping all arrays that work with the inversion as
C    real*8. 4) removing every blasted 'nbug' statement i could
C    get my hands on!! 5) reading the data once storing everything in
C    memory -ie. not reading the data twice. 6) changing all logical
C    true and false statements to user friendly statements.
C 7) this program could be faster by inverting only the half of
C    the symmetric covariance matrix (covm) and there probably is a
C    faster routine for searching for the closest points.
C
*****
C INPUT PARAMETERS .....
C
C NORTH...NORTH LATITUDE OF DATA AREA
C SOUTH...SOUTH LATITUDE OF DATA AREA
C WEST...WEST LONGITUDE OF DATA AREA
C EAST...EAST LONGITUDE OF DATA AREA
C
C note: use the following example if you want an equal-
C    area projection. say you are working at the south
C    pole from -40S to -83S and including all longitudes.
C    then instead of choosing north=-40, south=-83,
C    west=-180 and east=180 (which are appropriate for
C    non-equal area degrees) choose instead:
C    north=-55, south=-55, west=-55, east=55. 55 comes
C    from the following calculation. from -40 to

```

```

c      -83 degrees is 43 points, however, an equal area
c      projection will go all the way to the pole because
c      the pole will be centered at the middle of the grid
c      (unlike the non-equal area degree projection where
c      the pole is at the southern edge of the grid) so,
c      from -40 to -90 is 50 points and you should add a few
c      points for a rind around the edge, say 5 points.
c      55-50+5.  get it?  now, if you are going to work with
c      an equal area projection, you MUST transform the
c      coordinates of the input data points from the degree
c      domain to the spatial domain.  program getllraspc.f does
c      this transformation.  also, if you want to convert a
c      grid from/to equal-area to/from non-equal degree then
c      use program deg2spc.f to do the coordinate transform
c      and use collocation to get the values at the new grid
c      coordinates.  clear as mud, eh?  email me at
c      alsdorf@geols.mps.ohio-state.edu
c      if you need help.
c
c      NX...NO. OF GRID PTS IN THE LONG. DIRECTION, MINUS ONE
c      NY...NO. OF GRID PTS IN THE LAT. DIRECTION, MINUS ONE
c      NCOV...NUMBER OF ENTRIES IN COVARIANCE FUNCTION
c      and is determined by the program
c      NCPP...NO. OF NEAREST POINTS USED FOR PREDICTION
c      ELEV...COMMON ALTITUDE FOR GRIDDED ANOMALY DATA
c      and is in kilometers from --SURFACE-- of the earth
c      ESTD...STANDARD DEVIATION OF OBSERVATIONAL ERROR
c      (ERROR VARIANCE=ESTD**2)
c      from read of file 10
c      THI...LATITUDE COORDINATE
c      PHI...LONGITUDINAL COORDINATE
c      RAD...RADIUS VECTOR FROM --CENTER-- OF THE EARTH
c      ANO...ANOMALY VALUE
c
c
c      GRID DIMENSIONS AS FOLLOWS:
c      the following arrays = (ny+1)*(nx+1):
c      x,y,tp,ifc,1h,sep
c      the following arrays must be equal to or greater than
c      the maximum number of data points:
c      rrad,rthi,rphi,tano,dist,thii,phi,rad,anom
c      ARRAYS CNN, DNUM MUST ACCOMMODATE THE NUMBER OF ENTRIES
c      IN COVARIANCE FUNCTION
c
c      CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
c      IMPLICIT REAL (A-H,O-Z)
c      DIMENSION X(20000),Y(20000),TP(20000),CNN(500),
c      .      DNUM(500),RRAD(200000),RTHI(200000),RPHI(200000),
c      .      TANO(200000),
c      .      DIST(200000),IFC(20000),THII(200000),PHII(200000),
c      >      RADD(200000),ANOM(200000),IH(20000),SEP(20000)
c      REAL      NORTH
c      real thi,phi,rad,anom,cross
c      integer totpts
c      character*80 filename
c      character*5 yesno
c      real dnum,cnn, scale,sumsqr
c      COMMON/ONE/ CNN,DNUM,NCOV
c      COMMON/TWO/ SCALE
c      DATA RHO,NPTS/57.2957795,0/
c
c      write (*,*) 'INPUT COVARIANCE MATRIX'
c      read (*,9990) filename
c      9990 format (a80)
c      open (1, file=filename,status='old',form='formatted')
c      write (*,*) 'INPUT FILE OF ALL DATA POINTS LAT LON RAD ANOM'
c      read (*,9990) filename
c      open (10, file=filename,status='old',form='formatted')
c      write (*,*) 'OUTPUT FILE OF GRIDDED DATA POINTS'
c      read (*,9990) filename
c      open (20, file=filename,form='formatted')
c      write (*,*) 'OUTPUT INFORMATION FILE'
c      read (*,9990) filename
c      open (21, file=filename,form='formatted')
c
c      write (*,*) 'BARF-- NORTH SOUTH EAST WEST AS 90.0 TO -90.0',
c      >      ' AND 180.0 TO -180.0'
c      read (*,*) north,south,east,west
c      write (*,*) 'NUMBER OF GRID POINTS MINUS ONE IN THE NS DIRECTION'
c      write (*,*) 'NUMBER ----- EW -----'
c      write (*,*) 'NS, EW '
c      read (*,*) ny,nx
c      write (*,*) 'POINT SIZE OF WINDOW FOR SEARCH AREA (20)'
c      read (*,*) ncpp
c      write (*,*) 'ELEVATION OF PREDICTION FOR GRID (350.0 Km)'
c      write (*,*) '(-NOT-- radius = 6378.140 Km)'
c      read (*,*) elev
c      elev=elev+6378.140

```

```

        write (*,*) 'STANDARD DEVIATION OF OBSERVATIONAL ERROR (1.0)'
        read (*,*) estd
        write (*,*) 'REMOVE THE MEAN FROM THE GRID BEFORE WRITTING'
        write (*,*) 'y OR n'
        read (*,9991) yesno
9991 format (a5)
c
c     If(EAST.EQ.WEST.OR.NORTH.LE.SOUTH.OR.NY.LE.0.OR.NX.
c         .      LE.0) STOP 9999
c
c     CHANGE LATITUDES TO SPHERICAL COORDINATES
c
c     NORTH=90.0-NORTH
c     SOUTH=90.0-SOUTH
c
c----- the program is checking for the -180.0 180.0 meridian
c
c     cross=0.0
c     IF(WEST.GT.EAST) cross=360.0
c     EAST=EAST + cross
c
c     INPUT THE COVARIANCE TABLE
c
c     I=1
5    read (1,*,end=7) dnum(i),cnn(i)
        i=i+1
        go to 5
7    ncov=i-1
        SCALE=cnn(1)
c
c     GRID SPACING ..ie: interval between grid nodes = dl and dp
c
c     DP=(NORTH-SOUTH)/FLOAT (NY)
c     DL=( EAST-WEST )/FLOAT (NX)
c
c .. DETERMINE THE OVERLAPS IN X AND Y-DIRECTIONS
c
c     YOVLAP=DP/2.
c     XOVLAP=DL/2.
c
c .. NXP1,NYP1 = NUMBER OF SORT ELEMENTS IN X AND Y-DIR.
c .. XLL,XUP = LOWER AND UPPER X LIMITS OF SORT RANGE
c .. YLL,YUP = LOWER AND UPPER Y LIMITS OF THE SORT RANGE
c .. NX,NY = NUMBER OF DIVISIONS ALONG X AND Y AXES
c     DETERMINE X,Y COORDINATES OF GRID INTERSECTIONS
c
c     NXP1=NX + 1
c     NYP1=NY + 1
c     DO 10 I=1,NYP1
c         YY=DP*(I-1)+YOVLAP
c         DO 10 J=1,NXP1
c             K=J+NXP1*(I-1)
c             Y(K)=YY
c             X(K)=DL*(J-1)+XOVLAP
10   CONTINUE
c
c     DETERMINE THE X,Y COORDINATES OF THE DATA AREA AND
c     GRID SPACING
c
c     XLL=0.
c     XUP=X(NXP1)+XOVLAP
c     YLL=0.
c     YUP=Y(NXP1*NYP1)+YOVLAP
c     DXX=NXP1/(XUP-XLL)
c     DYY=NYP1/(YUP-YLL)
c
c     DETERMINE BOUNDARIES FOR DATA SELECTION
c
c     THIS=SOUTH-YOVLAP
c     THIN=NORTH-YOVLAP
c     EPHI=EAST+XOVLAP
c     WPHI=WEST-XOVLAP
c
c----- varn is a constant for input to subroutine
c     prdt. varn should be change to an array for
c     corresponding individual data points if each
c     data point or group of data points need to have
c     individually different error variances.
c
c     varn=estd**2
c
c     write (21,*) 'north colatitude =',north,' south colat =',south
c     write (21,*) 'east longitude =',east,' west long =',west
c     write (21,*) 'dp =',dp,' dl =',dl,' xoqlap =',xoqlap,
c     >      ' yoqlap =',yoqlap
c     write (21,*) 'thin =',thin,' this =',this,' ephi =',ephi,
c     >      ' wphi =',wphi
c     write (21,*) 'xll =',xll,' xup =',xup,' yll =',yll,' yup =',yup
c     write (21,*) 'dxx =',dxx,' dyy =',dyy
c     write (21,*) 'error variance =',varn,
c     >      ' standard deviation error =',estd
c

```

```

C INPUT ADJUSTED MAGNETIC DATA AND SELECT DATA FOR
C THE PREDICTION
C
C      np=(nxpl+1)*(nyp1+1)
C      do 15 i=1,np
C          ifc(i)=0
C 15  continue
C
C      AMEAN=0.0
C      totpts=0
C 20  read (10,*,end=30) thi,phi,rad,anomaly
C      totpts=totpts+1
C      THI=90.0-THI
C      IF (THI.GE.THIS) GO TO 20
C      IF (THI.LE.THIN) GO TO 20
C      IF (PHI .LT. 0.0) PHI=PHI + cross
C      IF (PHI.LE.WPHI) GO TO 20
C      IF (PHI.GE.EPHI) GO TO 20
C      NPTS=NPTS + 1
C      AMEAN=AMEAN + anomaly
C      RX=PHI-WPHI
C      RY=THI-THIS
C
C      IX AND IY IDENTIFIES THE BLOCK TO WHICH DATA FALL INTO
C      AND IYJX ASSIGNS AN IDENTIFIER TO DATA CORRESPONDING TO
C      THAT BLOCK
C
C      IY=INT((RY-YLL)*DYY)+1
C      JX=INT((RX-XLL)*DXX)+1
C      IYJX=(IY-1)*NXP1+JX
C
C .. IFC = COUNTER VECTOR , STORES NUMBER OF DATA PER
C     SORT ELEMENT
C
C      IFC(IYJX)=IFC(IYJX)+1
C
C      thi(npts)=thi
C      phi(npts)=phi
C      radd(npts)=rad
C      anom(npts)=anomaly
C
C      GO TO 20
C
C 30  continue
C      if (npts .le. 1) stop 111
C
C      AMEAN=AMEAN/FLOAT(NPTS)
C
C      WRITE(21,*) 'total points selected =',npts
C      write (21,*) 'total points read =',totpts
C      write (21,*) 'mean of selected points =',amean
C      write (*,*) 'finished reading data set'
C
C      IH = POINTER VECTOR, FOR CORRESPONDING BLOCK ATTAINS
C      A VALUE EQUAL TO SUM OF DATA IN PREVIOUS BLOCKS + 1
C
C      ND=NXP1*NYP1
C      IH(1)=1
C      DO 87 I=2,ND
C          I1=I-1
C          IH(I)=IFC(I1)+IH(I1)
C 87  CONTINUE
C
C      TX,TY,RTHI,RPHI,RRAD,TANO,VARN ARE NUMBERED FOR
C      CORRESPONDING DATA, IN EACH BLOCK NUMBERING STARTS
C      WITH IH VALUE FOR THAT BLOCK AND INCREMENTED BY 1 FOR
C      NEXT DATA IN THE BLOCK
C
C      the mean anomaly value is removed here rather than in subroutine prdt.
C      also the sum of squares is calculated here and transferred to
C      subroutine prdt.
C
C      sumsqr=0.0
C      DO 85 I=1,NPTS
C          RX=phi(i)-wphi
C          RY=thi(i)-this
C          IY=INT((RY-YLL)*DYY)+1
C          JX=INT((RX-XLL)*DXX)+1
C          IYJX=(IY-1)*NXP1+JX
C          NUM=IH(IYJX)
C          TANO(NUM)=anom(i)-amean
C          sumsqr=sumsqr+(dble(tano(num))*dble(tano(num)))
C          RTHI(NUM)=thi(i)
C          RPHI(NUM)=phi(i)
C          RRAD(NUM)=radd(i)
C          IH(IYJX)=IH(IYJX)+1
C 85  CONTINUE
C
C      IH(I) ATTAINS THE VALUE EQUAL TO NUMBER OF SAMPLE
C      POINTS IN PREVIOUS BLOCKS + 1

```

```

      DO 86 I=1,ND
      IH(I)=IH(I)-IFC(I)
86  CONTINUE
      IH(ND+1)=NPTS+1
C
C SUBROUTINE PRDT PREDICTS ANOMALIES AND ERRORS OF
C STANDARD DEVIATION AT EACH GRID LOCATION
C
C
      write (*,*) 'calculating anomaly values'
C
      CALL PRDT(NPTS,NYP1,NXP1,X,Y,TP,RH1,RPHI,DIST,
      .   VARN,THIS,TANO,NORTH,SOUTH,EAST,WEST,IH,DXX,DYY,DP,
      .   DL,AMean,RRAD,NCPP,ELEV,SEP,sumsqr)
C
C
C WRITE THE VALUES OF THE PREDICTED Z-AXIS VALUES
C (ANOMALIES) AND THEIR ERROR OF STANDARD DEVIATIONS.
C THE ROWS ARE LISTED WITH LATITUDES STARTING SOUTH
C AND INCREMENTING TO NORTH.
C
      if (yesno .eq. 'y') then
      np=nxp1*nyp1
      do 380 i=1,np
      totgrid=tp(i)+totgrid
380  continue
      avgrid=totgrid/real(np)
      do 390 i=1,np
      tp(i)=tp(i)-avgrid
390  continue
      write (21,*) 'total mean removed from the grid =',avgrid
      endif
C
      WRITE(21,9600) WEST,DL
      write (20,*) nyp1
      write (20,*) nyp1
      write (20,*) south
      write (20,*) west
      write (20,*) dl
      P=SOUTH
      DO 400 I=1,NYP1
      ID1=(I-1)*NXP1+1
      ID2=ID1+NXP1-1
      WRITE(21,9601) P,(TP(J),J-ID1,ID2)
      WRITE(20,'(6F13.5)') (TP(J),J=ID1,ID2)
400  P=P + DP
C
      WRITE(21,9602) WEST,DL
      P=SOUTH
      DO 420 I=1,NYP1
      ID1=(I-1)*NXP1+1
      ID2=ID1+NXP1-1
      WRITE(21,'(6F13.5)') (SEP(J),J=ID1,ID2)
420  P=P + DP
C
      9600 FORMAT(//,'PREDICTED Z-AXIS VALUES',//,
      .   'STARTING LONGITUDE-',F9.3,': INCREMENT-',F5.2,/)
      9601 FORMAT('LAT-',F8.2,2X,80(8F8.2,/,14X))
      9602 FORMAT(//,'PREDICTED STANDARD DEVIATIONS',//,
      .   'STARTING LONGITUDE-',F9.3,': INCREMENT-',F5.2,/)
C
      STOP
      END
C
C
C SUBROUTINE PRDT(NPTP,MY,MX,X,Y,TP,LAT,LONG,DIST,
C   .   NSEE,THIS,M1,THI1,THI2,PHI11,PHI21,IH,DXX,DYY,DP,DL,
C   .   AMEAN,RC,NCPP,ELEV,SEP,sumsqr)
      IMPLICIT REAL (A-H,O-Z)
      REAL NSEE,LAT,LONG,M1
      real scale,covm,fact,sumsqr,var,nse,dummy,b,
      >   t1,t2,tem,tem2,cov
      DIMENSION LAT(1),LONG(1),DIST(1),M1(1),RC(1),
      >   X(1),Y(1),TP(1),IH(1),SEP(1)
      DIMENSION COVM(110,110),B(110),T1(110),T2(110),LCC(110)
      COMMON/TWO/ SCALE
      DATA DMAX/6E6/
      EQUIVALENCE (B(1),T1(1))
C
C
      nse=dble(nsee)
      CON1=57.2957795
      ND=MY*MX
      NBAD=0
      Y1,L=0,0
      -----
      ----- subroutine description
      this subroutine is one big do loop that progresses through
      the grid nodes to determine the magnitude at each node.
C
      nse=dble(nsee)
      CON1=57.2957795
      ND=MY*MX
      NBAD=0
      Y1,L=0,0

```

```

XLL=0.0
C   CALCULATE THE SCALING FACTOR FOR THE COVARIANCE TABLE
C
C   fact = (sumsqr/dble(nptp))/scale
C
C   CALL COVINT(0.0,FACT,VAR)
C
C   write (21,*) 'sum of squares =',sumsqr,' scaling factor =',FACT
C   write (21,*) 'zero separation variance =',var
C
C   NCPM1=NCPP-1
C   IND=0
C
C   P AND Q ARE THE LATITUDE AND LONGITUDE OF THE
C   PREDICTED POINT
C
C   write (21,*) ''
C   write (21,*) 'the following data indicate areas where the'
C   write (21,*) 'prediction was bad'
C   write (21,*) 'lat lon x grid node y gridnode id1 id2 '
C   >           'bad point number of total points'
C
C   DO 10 IPT=1,MY
C   IM=IPT-1
C   P=THI2+IM*DP
C   DO 10 JPT=1,MX
C   JM=JPT-1
C   Q=PHI2+JM*DL
C   IND=IND+1
C   XPP=X(IND)
C   YPP=Y(IND)
C   DO 7 I=1,NCPP
C   LCC(I)=0
C
C   DISTANCE TO ALL POINTS IN THE WINDOW FROM PREDICTION
C   POINT
C
C   IY=INT((YPP-YLL)*DYY)+1
C   JX=INT((XPP-XLL)*DXX)+1
C   IYJX=(IY-1)*MX+JX
C   ID1=IH(IYJX)
C   ID2=IH(IYJX+1)
C   IF((ID2-ID1).GE.NCPP) GO TO 100
C
C   NOT ENOUGH DATA IN FIRST WINDOW, SO CONSIDER NEXT
C   WINDOW
C
C   IY1=IY
C   IY2=IY
C   DO 17 IC=1,MY
C   NDATA=0
C   IY1=IY-IC
C   IY2=IY+IC
C   IF(IY1.LT.1) IY1=1
C   IF(IY2.GT.MY) IY2=MY
C   JX1=JX-IC
C   JX2=JX+IC
C   IF(JX1.LT.1) JX1=1
C   IF(JX2.GT.MX) JX2=MX
C   DO 18 IL=IY1,IY2
C   IYJX1=(IL-1)*MX+JX1
C   ID1=IH(IYJX1)
C   IYJX2=IYJX1+JX2-JX1+1
C   ID2=IH(IYJX2)
C   NDATA=NDATA+ID2-ID1
C
18   CONTINUE
C   IF(NDATA.GE.NCPP) GO TO 100
C   NBAD=NBAD+1
C----- write the bad point to file
C
800  WRITE(21,800) P,Q,XPP,YPP, ID1, ID2, NBAD, ND
C   FORMAT(4(1x,F12.5),4I6)
17   CONTINUE
100  CONTINUE
DO 211 IC=IY1,IY2
C   IF(IY1.EQ.IY2) GO TO 106
C   IYJX1=(IC-1)*MX+JX1
C   ID1=IH(IYJX1)
C   IYJX2=IYJX1+JX2-JX1+1
C   ID2=IH(IYJX2)-1
C   IF(ID2.LT.ID1) GO TO 211
C
106  DO 210 I=ID1, ID2
C   DELC=COS(LAT(I)/CON1)*COS(P/CON1)+SIN(LAT(I)/CON1)*
C   >           SIN(P/CON1)*COS((LONG(I)-Q)/CON1)
C   PART1=ELEV**2 + RC(I)**2
C   PART2=2.0*ELEV*RC(I)
C   DARGU=PART1-PART2*DELC
C   IF(DARGU.LE.0.0) THEN
C   DIST(I)=0.0

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        ELSE
            DIST(I)=SQRT(DARGU)
        END IF
210      CONTINUE
211      CONTINUE
C
C SEARCH FOR NCPP NEAREST POINTS TO PREDICTION POINT
C
220      DO 260 J=1,NCPP
        IF(LCC(J).GT.0) GO TO 260
        DMIN=DMAX
        DO 253 IC=IY1,IY2
            IF(IY1.EQ.IY2) GO TO 107
            IYJX1=(IC-1)*MX+JX1
            ID1=IH(IYJX1)
            IYJX2=IYJX1+JX2-JX1+1
            ID2=IH(IYJX2)-1
            IF(ID2.LT.ID1) GO TO 253
107        DO 250 I=ID1, ID2
            IF(DIST(I)-DMIN) 230,250,250
            IF(DIST(I)) 250,240,240
            DMIN=DIST(I)
            LMIN=I
250        CONTINUE
253        CONTINUE
        DIST(LMIN)--DMIN
        LCC(J)=LMIN
260        CONTINUE
        IF(LCC(NCPP).NE.0) GO TO 258
        GO TO 220
258        CONTINUE
C
C FORM COVARIANCE MATRIX
C
        DO 280 I=1,NCPM1
        M=LCC(I)
        COVM(I,I)=dble(VAR+NSE)
        K=I+1
        DO 280 J=K,NCPP
        N=LCC(J)
        DELC=COS(LAT(M)/CON1)*COS(LAT(N)/CON1)+SIN(LAT(M)/
        CON1)*SIN(LAT(N)/CON1)*COS((LONG(M)/
        -LONG(N))/CON1)
        PART1=RC(M)**2 + RC(N)**2
        PART2=2.0*RC(M)*RC(N)
        DARGU=PART1-PART2*DELC
        IF(DARGU.LE.0.0) THEN
            DIS=0.0
        ELSE
            DIS=SQRT(DARGU)
        END IF
C
        CALL COVINT(DIS,FACT,COV)
C
        COVM(J,I)=dble(COV)
        COVM(I,J)=dble(COV)
280        CONTINUE
        COVM(NCPP,NCPP)=dble(VAR+NSE)
C----- covm array dimensioned at
C----- (ncpp,ncpp) is the input matrix
C
C INVERT COVARIANCE MATRIX
C
        COVM(1,1)=1.0/COVM(1,1)
        DO 340 I=1,NCPM1
        L=I+1
        DO 300 J=1,I
        B(J)=0.0
300        DO 310 J=1,I
        DO 310 K=1,I
        B(J)=B(J)-COVM(K,J)*COVM(L,K)
        Dummy=COVM(L,L)
        DO 320 J=1,I
        Dummy=B(J)*COVM(L,J)+Dummy
        Dummy=1.0/Dummy
        DO 330 J=1,I
        COVM(J,L)=B(J)*Dummy
        COVM(L,J)=B(J)*Dummy
        DO 330 K=1,I
        COVM(J,K)=COVM(J,K)+B(K)*B(J)*Dummy
330        COVM(L,L)=Dummy
C----- covm array dimensioned at
C----- (ncpp,ncpp) is now inverted
C
        DO 410 I=1,NCPP
        N=LCC(I)
        DELC=COS(LAT(N)/CON1)*COS(P/CON1)+SIN(LAT(N)/CON1)*
        SIN(P/CON1)*COS((LONG(N)-Q)/CON1)
        PART1=RC(N)**2 + ELEV**2

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        PART2=2.0*ELEV*RC(N)
        DARGU=PART1-PART2*DELC
        IF (DARGU.LE.0.0) THEN
          DIS=0.0
        ELSE
          DIS=SQRT (DARGU)
        END IF
      C
      C          CALL COVINT (DIS,FACT,COV)
      C
      410    T1(I)=dble(COV)
      C
      DO 430 I=1,NCPP
        TEM=0.0
        DO 420 J=1,NCPP
          TEM=COVM(J,I)*T1(J)+TEM
      420    T2(I)=TEM
      C
        TEM=0.0
        TEM2=0.0
        DO 440 I=1,NCPP
          M=LCC(I)
          TEM=dble(M1(M))*T2(I)+TEM
          TEM2=T1(I)*T2(I)+TEM2
      440    CONTINUE
      C
      C  COMPUTE ANOMALY ESTIMATE  AND STANDARD ERROR OF PREDICTION
      C
        TP(IND)=real(TEM)+AMEAN
        IF (VAR.LT.TEM2) GO TO 444
        SEP(IND)=SQRT (VAR-TEM2)
        GO TO 445
      444    SEP(IND)=1.5
        WRITE(21,446) VAR,TEM2
      446    FORMAT('VARIANCE =',F7.2,'TEM2 =',F7.2,'SEP',
        ' TAKEN AS 1.5 NT')
      445    CONTINUE
      10  CONTINUE
      C
      RETURN
      END
      C
      C
      C          SUBROUTINE COVINT (DIS,FACT,COV)
      C          IMPLICIT REAL (A-H,O-Z)
      C          real dis
      C          integer ncov
      C          DIMENSION CNN(500),DNUM(500)
      C          COMMON/ONE/ CNN,DNUM,NCOV
      C
      C----- INTERPOLATION OF COVARIANCES
      C
      TCOV=dble(NCOV-1)
      R1=dble(DIS)
      IF (R1.LT.TCOV) GO TO 1
      COV=CNN(NCOV)*FACT
      WRITE(21,100) R1
      RETURN
      C
      1 IF (R1.GT.0.0001) GO TO 6
      COV=CNN(1)*FACT
      RETURN
      C
      6 DO 2 I=1,NCOV
        IF (R1.LT.DNUM(I)) GO TO 3
      2 CONTINUE
      3 I=I-1
        FPINT=R1-DNUM(I)
        FDINT=DNUM(I+1)-DNUM(I)
        COV=CNN(I)+(CNN(I+1)-CNN(I))*FPINT/FDINT
        COV=COV*FACT
        RETURN
      C
      100 FORMAT('SEPARATION =',F10.3,' >500 KM  COVARIANCE VALUE FOR',
        '>      500 KM USED.')
      C
      END

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C-9

PAGE C-9 MICHAELLE COOK

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program fourier2d
character*80 filename
real xdata(361,361),ydata(361,361),xmean,ymean,
>    prcnt,delta,cuthi,cutlo,xlag,mincc,maxcc,short,long,
>    xcolat,ycolat,xlong,ylong,xgridspc,ygridspc,
>    minccin,maxccin,cxlag
integer xpassno,ypassno,file,xcol,xrow,ycol,yrow,
>    lhb,cc,npass,imean,head,spass,swind,
>    nwind,numfile,nxout,nyout,cnwind,udnwind,
>    numcc(10),numlhb(10),numed(10),numud(10),numrtp(10),
>    numberiv(10)
complex xcdata(512,512),ycdata(512,512)
common /rowcol/ xrow,xcol,yrow,ycol
common /fftifft/ nxout,nyout,prcnt,imean,fold,itypefold
common /lhbfft/ delta,cuthi,cutlo,xlag,npass,nwind
common /ccffit/ mincc,maxcc,minccin,maxccin,cnwind,cxlag
common /reals/ xdata,ydata
common /striking/ angl,ang2,spass,swind,slag
common /udcont/ uddelta,zcon,udxlag,udnwind
common /xyzderiv/ xyzdelta,nth,nway
common /rtp/ azm,xinc,dec
common /comps/ xcdata,ycdata
c-----program description
c
c        fourier2d is an all encompassing fourier analysis program!
c        subroutines include the fft for forward and inverse situations,
c        a bandpass filter which can be adjusted to perform low, high and
c        bandpass filtering of wave numbers, a correlation coefficient
c        filter which zeros out wavenumbers according to correlation
c        coefficients, a strike-dip filter to remove wavelengths in
c        degrees of direction, an upward-downward continuation filter,
c        a derivative filter for any of the three directions and a
c        reduction-to-pole filter for magnetic total field intensity data.
c
c        NOTE: the only data variables absolutely necessary as INPUT are
c              the number of rows and number of columns, the remaining
c              variables; zero,mean,pass-number and eight, are not needed.
c              but, mean can be an OUTPUT if desired.
c
c        NOTE: fourier2d is for two-dimensional data. if you have a
c              one-dimensional data set then use fourier1d. however,
c              in 1-d i have not yet implemented the continuation,
c              derivative or rtp filters.
c
c        program date: 10 jul 92
c              this code was an extensive modification of an earlier code
c              named fourmat.
c
c
c        NOTE: because there are 6 filters, there are about forty
c              zillion different combinations of filtering the fft'd
c              data. so, to accomodate all of these, the user must
c              first state how many times to run the filter (ilhb,
c              icc, etc) then must state the order where to run each
c              filter (arrays numhb, numcc, num etc.. hold these
c              user defined positions). note that with this scheme
c              any filter can be run multiple times. be sure to enter
c              only one filter for each position value. the
c              following example should clear things up:
c              say you want to first bandpass filter, then cc
c              filter and then bandpass filter again. then you
c              should set ilhb=2 and icc=1. then array numhb should
c              have the values 1 and 3 (for the first and third positions)
c              and array numcc should only have the value 2 (for the
c              second position.
c
c        write (*,*) 'OUTPUT FILE OF STATISTICS AND INFORMATION'
c        read (*,9990) filename
c        open (25,file=filename,form='formatted')
c
c        write (*,9989)
9989 format ('1 IF YOU HAVE ONLY ONE FILE TO BE FOURIERED',
>           '2 IF YOU HAVE TWO FILES TO BE COMPARED')
c        read (*,*) numfile
c
c        write (*,9988)
9988 format ('ENTER THE MAXIMUM NUMBER OF TIMES TO RUN EACH FILTER',
>           'ENTER 0 TO NOT RUN THE FILTER',
>           'BANDPASS, CORR.COEFF., STRIKE-DIP, UP/DN CONT., RTP, DERIV')
c        read (*,*) ilhb,icc,isd,iud,irtp,iderv
c
c        if (ilhb .gt. 0) then
c            write (*,*) 'BANDPASS SECTION:'
c            write (*,*) 'enter placement values in order ie. 2 3 5 '
c            write (*,*) 'do not repeat these values elsewhere'
c            write (*,*) '1-first, 3-third, 5-fifth etc...'
c            read (*,*) (numlhb(i),i=1,ilhb)
c            write (*,9993)
9993 format ('DELTA.....GRID INTERVAL IN MAP UNITS (1.0 degrees)'+
>           'SHORT.....SHORTEST WAVELENGTH TO BE PASSED'

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>           ' MUST BE AT LEAST 2*DELTA (2.0 degrees)'/
>           'LONG.....LONGEST WAVELENGTH TO BE PASSED'
>           'MUST BE LARGER THAN SHORT'/
>           'NPASS.....-1 TO REJECT WAVELENGTHS BETWEEN SHORT'/
>           ' AND LONG'/
>           ' 1 TO PASS WAVELENGTHS BETWEEN SHORT AND'/
>           ' LONG'/
>           ' NOTE : WAVENUMBER = 1/WAVELENGTH AND IS '/
>           ' CALCULATED BY THE PROGRAM'/
>           ' INPUT ORDER IS DELTA SHORT LONG NPASS')
read (*,*) delta,short,long,npass
write (*,9994)
9994 format (' NWIND..... TYPE OF WINDOW TO APPLY'
>           '- 0 GIVES NO WINDOW'/
>           '- 1 RECTANGULAR WINDOW'/
>           '- 2 BARTLETT WINDOW (TRIANGULAR)'/
>           '- 3 HAMMING-TUKEY WINDOW'/
>           '- 4 PARZEN WINDOW'/
>           ' XLAG.....SMOOTHING PARAMETER FOR WINDOWING IDEAL'/
>           ' FILTER IN SPATIAL DOMAIN (is disabled if'/
>           ' no window was chosen above).'/
>           ' nwind xlag')
read (*,*) nwind,xlag
c
cuthi=1.0/short
cutlo=1.0/long
RCUTLO=999999.99
IF (CUTLO .GE. 0.0000001 ) RCUTLO= 1.0/CUTLO
RCUTHI=1.0/CUTHI
WAVLEN=2.*DELTA
FNQ1=1.0/WAVLEN
WRITE (25,9987) FNQ1,WAVLEN,CUTLO,RCUTLO,CUTHI,RCUTHI
9987 FORMAT('NYQUIST WAVENUMBER =',F10.5,' CYCLES PER DATA INTERVAL'/,
>           'NYQUIST WAVELENGTH = ',F10.5,' LENGTH INTERVALS'/
>           'LOW WAVE# CUTOFF OF IDEAL FILTER = ',F10.5,
>           ' CYCLES PER DATA INTERVAL ',F15.5,
>           ' WAVELENGTH EQUIVALENT',
>           'HIGH WAVE# CUTOFF OF IDEAL FILTER = ',F10.5,
>           ' CYCLES PER DATA INTERVAL ',F15.5,
>           ' WAVELENGTH EQUIVALENT',//)
endif
c
if (icc .gt. 0) then
  if (numfile .ne. 2) then
    write (*,*) 'you must enter two files to run cc filter'
    stop
  endif
  write (*,*) 'CORRELATION COEFFICIENT SECTION:'
  write (*,*) 'enter placement values in order ie. 2 3 5 '
  write (*,*) 'do not repeat these values elsewhere'
  write (*,*) '1-first, 3=third, 5=fifth etc...'
  read (*,*) (numcc(i),i=1,icc)
  write (*,9995)
9995 format ('WHAT IS THE MINIMUM CORR COEF TO BE PASSED:(0.4)',//,
>           'WHAT IS THE MAXIMUM CORR COEF TO BE PASSED:(1.0)',//,
>           'MINIMUM INPUT CC WITHOUT WRITING WARNING',//,
>           'MAXIMUM INPUT CC WITHOUT WRITING WARNING',//,
>           'CNWIND..... TYPE OF WINDOW TO APPLY'
>           '- 0 GIVES NO WINDOW'/
>           '- 1 RECTANGULAR WINDOW'/
>           '- 2 BARTLETT WINDOW (TRIANGULAR)'/
>           '- 3 HAMMING-TUKEY WINDOW'/
>           '- 4 PARZEN WINDOW'/
>           'CXLAG.....SMOOTHING PARAMETER FOR WINDOWING IDEAL'/
>           ' FILTER IN SPATIAL DOMAIN (is disabled if'/
>           ' no window was chosen above).'/
>           'mincc maxcc minccin maxccin cnwind cxlag')
  read (*,*) mincc,maxcc,minccin,maxccin,cnwind,cxlag
endif
c
if (isd .gt. 0) then
  write (*,*) 'STRIKE-DIP SECTION:'
  write (*,*) 'enter placement values in order ie. 2 3 5 '
  write (*,*) 'do not repeat these values elsewhere'
  write (*,*) '1-first, 3=third, 5=fifth etc...'
  read (*,*) (numsd(i),i=1,isd)
  write (*,9986)
9986 format ('ANGLE 1: > 0.0 AND < ANGLE2',//,
>           'ANGLE 2: > ANGLE 1 AND <= 180.0',//,
>           ' 1 TO PASS AZIMUTHS BETWEEN ANGLES'//,
>           '-1 TO REJECT AZIMUTHS BETWEEN ANGLES'//,
>           'TYPE OF WINDOW TO APPLY TO FILTER',//,
>           ' 0 (NONE), 1 (RECTANGULAR), 2 (TRIANGULAR), 3 (H-T), 4 (PARZEN)'//,
>           'LAG VALUE ON SMOOTHING WINDOW (0.1 TO 99.9)'//,
>           ' ang1 ang2 spass swind slag')
  read (*,*) ang1,ang2,spass,swind,slag
endif
c
if (iud .gt. 0) then
  write (*,*) 'UP/DOWN CONTINUATION SECTION:'

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        write (*,*) 'enter placement values in order ie. 2 3 5 '
        write (*,*) 'do not repeat these values elsewhere'
        write (*,*) '1-first, 3-third, 5-fifth etc...'
        read (*,*) (numud(i),i=1,iud)
        write (*,9985)
9985 format('udDELTA - GRID INTERVAL IN MAP UNITS (1.0)',/
           >      'ZCON - DISTANCE TO CONTINUE THE DATA SET',/
           >      '    IN THE SAME LENGTH UNITS AS DELTA',/
           >      '(1.0 degree = 111 km)',/
           >      '    NEGATIVE FOR UPWARD CONTINUATION',/
           >      '    POSITIVE FOR DOWNWARD CONTINUATION',/
           >      'udNWIND - TYPE OF WINDOW TO APPLY TO FILTER',/
           >      '    0 (NONE), 1 (RECTANGULAR), 2 (TRIANGULAR)',/
           >      '    3 (H-T), 4 (PARZEN)',/
           >      'udXLAG - SMOOTHING PARAMETER FOR WINDOWING FILTER',/
           >      '    IN SPATIAL DOMAIN. DETERMINES WHAT PERCENTAGE',/
           >      '    DATA IS WINDOWED',/
           >      '    delta zcon udnwind udxlag')
        read (*,*) uddelta,zcon,udnwind,udxlag
        endif
c
        if (irtp .gt. 0) then
          write (*,*) 'REDUCTION TO POLE SECTION:'
          write (*,*) 'enter placement values in order ie. 2 3 5 '
          write (*,*) 'do not repeat these values elsewhere'
          write (*,*) '1-first, 3-third, 5-fifth etc...'
          read (*,*) (numrtp(i),i=1,irtp)
          write (*,9983)
9983 format ('AZM - AZIMUTH OF Y AXIS MEASURED IN DEGREES',/
           >      '    CLOCKWISE FROM TRUE NORTH',/
           >      'DEC - AVERAGE DECLINATION OF THE INPUTTED',/
           >      '    ANOMALY DATA',/
           >      'XINC - AVERAGE INCLINATION OF THE INPUTTED',/
           >      '    ANOMALY DATA',/
           >      '    azm dec xinc')
        read (*,*) azm,dec,xinc
        endif
c
        if (ideriv .gt. 0) then
          write (*,*) 'DERIVATIVE SECTION:'
          write (*,*) 'enter placement values in order ie. 2 3 5 '
          write (*,*) 'do not repeat these values elsewhere'
          write (*,*) '1-first, 3-third, 5-fifth etc...'
          read (*,*) (numderiv(i),i=1,ideriv)
          write (*,9984)
9984 format('xyzDELTA - GRID INTERVAL',/
           >      'NTH - ORDER OF SPATIAL DERIVATIVE TO PERFORM',/
           >      '    ON THE DATA',/
           >      'NWAY - DIRECTION IN WHICH TO CALCULATE THE',/
           >      '    DERIVATIVE',/
           >      '    0 - VERTICAL DERIVATIVE',/
           >      '    1 - HORIZONTAL DERIVATIVE IN "X" DIRECTION',/
           >      '    2 - HORIZONTAL DERIVATIVE IN "Y" DIRECTION',/
           >      '    xyzdelta nth nway')
        read (*,*) xyzdelta,nth,nway
        endif
c
        write (*,9992)
9992 format ('THE FOLLOWING REFERS TO FFT AND IFFT',/
           >      'NUMBER OF COLUMNS AND ROWS OF FFT ARRAY',/
           >      'AT A POWER OF 2: (256 128)(2 16 32 64 128 256 etc)',/
           >      'TYPE OF INPUT ARRAY INDICATES TYPE OF FOLDING TO BE USED',/
           >      '    0 IF A POLAR REGION, ie. E AND W EDGES ARE SAME',/
           >      '    1 IF A NON-POLAR REGION, ie. E AND W EDGES NOT SAME',/
           >      'PERCENT OF EACH EDGE OF INPUT ARRAY TO',/
           >      'BE FOLDED OUT: (0.1 TO 99.9)',/
           >      'PERCENT OF EACH EDGE OF FOLDED OUT OR NORMAL ARRAY',/
           >      'TO BE SMOOTHED TO ZERO: (0.1 TO 49.9)',/
           >      'DO NOT ADD MEAN TO IFFT DATA',/
           >      'ADD MEAN TO IFFT DATA',/
           >      'nxout nyout itypefold fold prcnt imean')
        read (*,*) nxout,nyout,itypefold,fold,prcnt,imean
c
        if (nxout .gt. 512 .or. nyout .gt. 512) then
          write (*,8999) nxout,nyout
8999  format (1x,'SORRY,16,1x,'OR',16,1x,'IS GREATER THAN 512 THE',/
           >      '    SIZE OF ARRAYS SET// IN THE SOURCE CODE',/
           >      '    YOU NEED TO ACCESS SOURCE CODE AND MAKE CHANGES')
          stop
        endif
c
        write (*,*) 'INPUT FILE 1'
        read (*,9990) filename
9990 format (a80)
        open (10, file=filename,status='old',form='formatted')
        if (numfile .eq. 2) then
          write (*,*) 'INPUT FILE 2'
          read (*,9990) filename
          open (11, file=filename,status='old',form='formatted')

```

```

        endif
        write (*,*) 'OUTPUT OF FILE 1'
        read (*,9990) filename
        open (20, file=filename,form='formatted')
        if (numfile .eq. 2) then
            write (*,*) 'OUTPUT OF FILE 2'
            read (*,9990) filename
            open (21, file=filename,form='formatted')
        endif
c
c
210  continue
        read (10,*) xcol
        read (10,*) xrow
        read (10,*) xcolat
        read (10,*) xlong
        read (10,*) xgridspc
        if (numfile .eq. 2) then
            read (11,*) ycol
        read (11,*) yrow
        read (11,*) ycolat
            read (11,*) ylong
        read (11,*) ygridspc
        endif
c
        xpassno=1
        ypassno=2
        do i=1,xrow
            read (10,*) (xdata(j,i),j=1,xcol)
        enddo
        if (numfile .eq. 2) then
            do i=1,yrow
                read (11,*) (ydata(j,i),j=1,ycol)
            enddo
        endif
c
        xmean=0.0
        call forwardft (1,xmean,xpassno)
        ymean=0.0
        if (numfile .eq. 2) call forwardft (2,ymean,ypassno)
c
        itottime=ilhb+icc+isd+iud+irtp+ideriv
        do i=1,itottime
            do j=1,ilhb
                if (numlhb(j) .eq. i) then
                    call filter (1)
                    if (numfile .eq. 2) call filter (2)
                    goto 888
                endif
            enddo
            do j=1,icc
                if (numcc(j) .eq. i) then
                    call correlate(xpassno,ypassno)
                    goto 888
                endif
            enddo
            do j=1,isd
                if (numsd(j) .eq. i) then
                    call strkpas(1)
                    if (numfile .eq. 2) call strkpas(2)
                    goto 888
                endif
            enddo
            do j=1,iud
                if (numudi(j) .eq. i) then
                    call upcon(1)
                    if (numfile .eq. 2) call upcon(2)
                    goto 888
                endif
            enddo
            do j=1,irtp
                if (numrtp(j) .eq. i) then
                    call mag2pol(1)
                    if (numfile .eq. 2) call mag2pol(2)
                    goto 888
                endif
            enddo
            do j=1,ideriv
                if (numderiv(j) .eq. i) then
                    call deriva(1)
                    if (numfile .eq. 2) call deriva(2)
                    goto 888
                endif
            enddo
c
888      continue
        enddo

```

```

c
c      call inverseft (1,xmean,xpassno)
c      if (numfile .eq. 2) call inverseft (2,ymean,ypassno)
c
c      write (20,*) xcol
c      write (20,*) xrow
c      write (20,*) xcolat
c      write (20,*) xlong
c      write (20,*) xgridspc
c      do i=1,xrow
c          write (20,9981) (xdata(j,i),j=1,xcol)
c      enddo
9981 format (5(f12.6,1x))
c      if (numfile .eq. 2) then
c          write (21,*) ycol
c          write (21,*) yrow
c          write (21,*) ycolat
c          write (21,*) ylong
c
c          write (21,*) ygridspc
c          do i=1,yrow
c              write (21,9981) (ydata(j,i),j=1,ycol)
c          enddo
c      endif
c
999  continue
close (10)
close (11)
close (20)
close (21)
close (25)
stop
end

c
c
c      subroutine forwardft (num,mean,passno)
c      integer num,xrow,xcol,yrow,ycol,nxout,nyout,passno,
c      >          row,col
c      real xdata(361,361),ydata(361,361),prcnt,mean
c      complex xcdat(512,512),ycdat(512,512)
c      common /fftifft/ nxout,nyout,prcnt,imean,fold,itypefold
c      common /rowcol/ xrow,xcol,yrow,ycol
c      common /reals/ xdata,ydata
c      common /comps/ xcdat,ycdat
c      COMMON H(512,512)
c      DIMENSION X(2,512,512)
c      COMPLEX H
c      double precision TSUM
c      EQUIVALENCE (X(1,1,1),H(1,1))

c      TSUM=0.0D0
c      if (num .eq. 1) then
c          row=xrow
c          col=xcol
c          do 50 i=1,row
c              do 50 j=1,col
c                  x(1,j,i) = xdata(j,i)
c                  tsum=tsum+x(1,j,i)
c 50      continue
c      elseif (num .eq. 2) then
c          row=yrow
c          col=ycol
c          do 80 i=1,row
c              do 80 j=1,col
c                  x(1,j,i) = ydata(j,i)
c                  tsum=tsum+x(1,j,i)
c 80      continue
c      endif
c
c*****PROGRAM SPA2FRQ
c
c      PROGRAM SPA2FRQ TRANSFORMS AN N X N MATRIX OF SPACE-DOMAIN
c      AMPLITUDES INTO THE N X N MATRIX OF WAVE NUMBER DOMAIN
c      COEFFICIENTS.  THE TRANSFORM MAY BE USED BY FIVE
c      IN-CORE PROGRAMS TO PERFORM SPECTRAL OPERATIONS (UPCON,MAGPOL,
c      BANDPASS,STRKPASS,DERIV).  FUNCTIONS PERFORMED BY THIS PROGRAM
c      INCLUDE :
c          - REMOVAL OF THE MEAN FROM THE DATA
c          - OPTIONAL WINDOWING OF THE EDGES OF THE DATA SET
c          - PADDING OF THE DATA SET WITH ZEROES TO ACHIEVE NECESSARY
c              SIZE (A POWER OF TWO)
c          - FORWARD TRANSFORM OF THE DATA
c
c.....REQUIRED SUBROUTINES :
c
c      FFT2D, FORK, DATWND

```

```

C
C.....DIMENSIONING REQUIREMENTS :
C
C      X (2,N,N).....WHERE N IS THE NUMBER OF COLUMNS AND ROWS OF THE
C      H (N,N)      OUTPUT TRANSFORMED MATRIX. N MUST BE AN INTEGRAL
C                  POWER OF TWO (2,4,8,16...).
C
C      NOTE : DIMENSIONS IN EVERY SUBROUTINE MUST BE
C      SET EQUAL TO DIMENSIONS IN MAIN PROGRAM.
C
C.....AUTHOR : SUBROUTINES FFT2D AND FORTH ARE MODIFIED FROM JON REED,
C
C                  PURDUE UNIVERSITY, DECEMBER 1980.
C
C      ALL OTHER CODE WRITTEN BY:
C
C      JEFFREY E. LUCIUS
C      GEOPHYSICAL INTERACTIVE COMPUTING LABORATORY
C      DEPARTMENT OF GEOLOGY AND MINERALOGY
C      THE OHIO STATE UNIVERSITY
C      COLUMBUS, OHIO 43210
C
C      MARCH 25, 1985 (REVISED DEC 5, 1986)
C
C      revised once again for DEC workstations on 6 APR 90 so that
C      that this beast is actually user friendly!
C
C      revised again (judas priest this is getting old) on
C      1 AUG 90 into this present format of all fourier programs
C      combined into this program.
C*****
C
C      IF(2**INT ALOG(FLOAT(NXOUT))/ALOG(2.0)+0.01).NE.NXOUT) THEN
C          WRITE(6,1030)
C          STOP
C      ENDIF
C      IF(2**INT ALOG(FLOAT(NYOUT))/ALOG(2.0)+0.01).NE.NYOUT) THEN
C          WRITE(6,1040)
C          STOP
C      ENDIF
C
C.....CALCULATE AND REMOVE THE MEAN
C
C      nxin=col
C      nyin=row
C      ICOL=nxin
C      IROW=nyin
C      XMEAN1=TSUM/FLOAT(NXIN*NYIN)
C      DO 210 IY=1,NYIN
C          DO 210 IX=1,NXIN
C              X(1,IX,IY)=X(1,IX,IY)-XMEAN1
C210  CONTINUE
C      WRITE(25,1020) XMEAN1
C
C.....WINDOW THE EDGES VIA DATWND
C
C      CALL DATWND (PRCNT,NXIN, NYIN, NXOUT, NYOUT, fold, itypefold)
C
C.....MATRIX IS NOW ZERO FILLED TO NXOUT BY NYOUT SIZE
C
C      CALCULATE AND REMOVE THE MEAN INTRODUCED BY TAPERING
C
C      TSUM=0.0
C      DO 214 IY=1,NYOUT
C          DO 214 IX=1,NXOUT
C              TSUM=TSUM+X(1,IX,IY)
C214  CONTINUE
C      XMEAN2=TSUM/FLOAT(NXOUT*NYOUT)
C      DO 215 IY=1,NYOUT
C          DO 215 IX=1,NXOUT
C              X(1,IX,IY)=X(1,IX,IY)-XMEAN2
C215  CONTINUE
C      WRITE(25,1020) XMEAN2
C      XMEAN=XMEAN2+XMEAN1
C
C      WRITE(25,1080) XMEAN
C      write (25,*) passno,xmean1,xmean2,xmean
C
C.....TRANSFORM DATA TO THE WAVENUMBER DOMAIN
C
C      NX=NXOUT
C      NY=NYOUT
C      CALL FFT2D(NX,NY,-1)
C
C      mean=xmean
C      if (num .eq. 1) then
C          do 500 iy=1,ny
C              do 500 ix=1,nx
C                  xcdata(ix,iy) = h(ix,iy)
C500      continue
C      elseif (num .eq. 2) then
C          do 580 iy=1,ny
C              do 580 ix=1,nx
C                  ycdata(ix,iy) = h(ix,iy)
C580      continue
C      endif

```

```

C      return
C
1020  FORMAT('MEAN REMOVED ',F15.7)
1030  FORMAT(1H , 'NXOUT MUST BE A POWER OF 2: SPA2FRQ FATAL')
1040  FORMAT(1H , 'NYOUT MUST BE A POWER OF 2: SPA2FRQ FATAL')
1080  FORMAT('TOTAL MEAN REMOVED ',F15.7)
C
C      END
C
C*****SUBROUTINE FFT2D (NX,NY,NSIGN)
C
C*****"FFT2D" PERFORMS BOTH A FORWARD OR INVERSE FAST FOURIER
C      TRANSFORM. "FFT2D" IS THE DRIVER THAT PASSES THE CORRECT VECTORS
C      TO "FORK" WHICH PERFORMS THE ACTUAL TRANSFORMING.
C      THE DIMENSIONING OF "H" MUST BE THE SAME AS IN THE MAIN PROGRAM
C
C      "NSIGN" = DIRECTION OF DESIRED TRANSFORMATION
C          --+1 INVERSE TRANSFORM (FREQUENCY TO SPATIAL)
C          ---1 FORWARD TRANSFORM (SPATIAL TO FREQUENCY)
C
C*****COMMON H(512,512)
C      COMMON CTEMP(512)
C      COMPLEX H,CTEMP
C
C      SIGNI=FLOAT(NSIGN)
C      IF(IABS(NSIGN).NE.1) THEN
C          WRITE(6,105)
C          STOP
C      ENDIF
C
C.....OPERATE BY ROWS
C
C      DO 101 IY=1,NY
101      CALL FORK (NX,H(1,IY),SIGNI)
C
C.....OPERATE BY COLUMNS
C
C      DO 104 IX=1,NX
C          DO 102 IY=1,NY
102          CTEMP(IY)=H(IX,IY)
          CALL FORK (NY,CTEMP,SIGNI)
          DO 103 IY=1,NY
103          H(IX,IY)=CTEMP(IY)
104      CONTINUE
C
C      RETURN
C
105  FORMAT(5X,'"NSIGN" MUST EQUAL +1 OR -1 FOR "FFT2D", FATAL')
C
C*****SUBROUTINE FORK (LXX,CX,SIGNI)
C
C*****FAST FOURIER TRANSFORM, MODIFIED FROM CLAERBOUT, J.F., FUNDAMENTAL
C      OF GEOPHYSICAL DATA PROCESSING, McGRAW-HILL, 1976
C      FORK USES COOLEY-TUKEY ALGORITHM.
C
C      "CX" = DATA VECTOR TO BE TRANSFORMED
C      "LXX" = LENGTH OF DATA VECTOR "CX" TO BE TRANSFORMED,
C          MUST BE A POWER OF 2 (LXX=2**INTEGER)
C      "SIGNI"= DIRECTION OF DESIRED TRANSFORMATION
C          --+1. INVERSE TRANSFORM (FREQUENCY TO SPATIAL)
C          ---1. FORWARD TRANSFORM (SPATIAL TO FREQUENCY)
C
C      NORMALIZATION PERFORMED BY DIVIDING BY
C          DATA LENGTH UPON THE FORWARD TRANSFORM.
C*****COMPLEX CX (LXX),CW,CTEMP,CON2
C
C      LX=LXX
C      LXH=LX/2
C      J=1
C      DO 103 I=1,LX
C          IF (I.LT.J) THEN
C              CTEMP=CX(J)
C              CX(J)=CX(I)
C              CX(I)=CTEMP
C          ENDIF
C          M=LXH

```

```

102      IF (J.GT.M) THEN
          J=J-M
          M=M/2
          IF (M.GE.1) GO TO 102
        ENDIF
        J=J+M
103    CONTINUE
        L=1
104    ISTEP=2*L
        CON2=(0.0, 3.14159265)/FLOAT(L)*SIGNI
        DO 105 M=1,L
          CW=CEXP(CON2*FLOAT(M-1))
          DO 105 I=M,LX,ISTEP
            CTEMP=CW*CX(I+L)
            CX(I+L)=CX(I)-CTEMP
105      CX(I)=CX(I)+CTEMP
        L=ISTEP
        IF (L.LT.LX) GO TO 104
        IF (SIGNI.GT.0.0) RETURN
          SC=1./FLOAT(LX)
C
        DO 106 I=1,LX
106      CX(I)=CX(I)*SC
C
        RETURN
      END
C
C*****SUBROUTINE DATWND (PRCNT,NX11,NY11,NX,NY,fold,itypefold)
C
C*****"DATWND" MULTIPLIES THE INPUT F(1,X,Y) BY A HALF BELL OF A HAMMIN-
C      TUKEY WINDOW ON ALL EDGES AND ZEROS OUT THE REMAINDER OF THE
C      (NX,NY) ARRAY.
C
C "PRCNT" =PERCENTAGE OF DATA TO BE ALTERED IN SMOOTHING TO ZERO
C      0.0 .LT. "PRCNT" .LE. 50.0
C
C update 2 feb 91
C      dat wnd has been considerably improved such that now the subroutine
C      performs three (count them, three !!) functions. one; a percentage
C      of the input matrix can be folded out. two; after folding out,
C      a new percentage of the folded out matrix (or regular data if
C      folding was not performed) can be smoothed to zero. three; the
C      manipulated data is centered within zeros to finish filling the
C      matrix to nx by ny size. because the actual data is now centered
C      within the transformed array, it is necessary to use the
C      do loops in subroutine inverseft to correctly extract the actual
C      data
C
C*****dimension holdme(512,512)
C      COMMON F(2,512,512)
C
C      nx1=nx11
C      ny1=ny11
C
C----- fold out the data based on percentage
C
C      if (fold.gt.0.0 .and. fold.lt.100.0) then
C
C        KX=Int(fold*FLOAT(NX1)/100.0+0.5)
C        KY=Int(fold*FLOAT(NY1)/100.0+0.5)
C        if (kx>nx1 .gt. nx) kx=(nx-nx1)/2
C        if (ky>ny1 .gt. ny) ky=(ny-ny1)/2
C        do j=1,ny1
C          do i=1,nx1
C            holdme(i,j)=f(1,i,j)
C          enddo
C        enddo
C----- fold out the columns in each row:
C      if itypefold is 1 then the data is considered to
C      be a rectangular style of projection where
C      the east and west edges of the data are not
C      covering the same geographic region. therefore,
C      the folding out of data along a row is symmetric
C      with respect to the individual edge.
C
C      if (itypefold .eq. 1 ) then
C        do j=1,ny1
C          do i=1,nx1+kx+kx
C            if (i.le.kx) f(1,i,j)=holdme(kx-1+j,j)
C            if (i.gt.kx .and. i.le.(kx+nx1)) f(1,i,j)=holdme(i-kx,j)
C            if (i.gt.(kx+nx1)) f(1,i,j)=holdme((2*nx1+kx+1-i),j)
C          enddo
C        enddo

```

```

c----- if itypefold is 0 then the array is considered to
c           be a polar style of projection where the east and
c           west edges are covering the same geographic area.
c           therefore, the folding along each row is actually
c           adding the western edge of data to the eastern
c           edge and eastern data to western edge.
c
c   elseif (itypefold .eq. 0) then
c       do j=1,ny1
c           do i=1,nx1+kx+kx
c               if (i.le.kx) f(1,i,j)=holdme(nx1+i-kx,j)
c               if (i.gt.kx .and. i.le.(kx+nx1)) f(1,i,j)=holdme(i-kx,j)
c               if (i.gt.(kx+nx1)) f(1,i,j)=holdme((i-nx1-kx),j)
c           enddo
c       enddo
c   endif
c
c   if (ny1 .eq. 1) go to 333
c   do j=1,ny1
c       do i=1,nx1+kx+kx
c           holdme(i,j)=f(1,i,j)
c       enddo
c   enddo
c----- fold out the rows in each column
c   do i=1,nx1+kx+kx
c       do j=1,ny1+ky+ky
c           if (j.le.ky) f(1,i,j)=holdme(i,ky-j+1)
c           if (j.gt.ky .and. j.le.(ky+ny1)) f(1,i,j)=holdme(i,j-ky)
c           if (j.gt.(ky+ny1)) f(1,i,j)=holdme(i,(2*ny1+ky+1-j))
c       enddo
c   enddo
c
c   ny1=ny1+2*ky
c   333 nx1=nx1+2*kx
c   endif
c
c   if (prcnt.gt.0.0 .and. prcnt.lt.50.0) then
c       KX=IFIX(PRCNT*FLOAT(NX1)/100.0+0.5)
c       KY=IFIX(PRCNT*FLOAT(NY1)/100.0+0.5)
c
c.....APPLY WINDOW TO COLUMNS
c
c       IF (NY1.NE.1 .AND. KY.NE.0) THEN
c           RKYPI= 3.14159265/FLOAT(KY)
c           DO 10 IY=1,KY
c               FACTOR=0.5*(1.0+COS(FLOAT(KY-IY+1)*RKYPI))
c               IYY=NY1-IY+1
c               DO 10 IX=1,NX1
c                   F(1,IX,IY) = F(1,IX,IY) * FACTOR
c               10 F(1,IX,IYY)= F(1,IX,IYY)* FACTOR
c           ENDIF
c
c.....APPLY WINDOW TO ROWS
c
c       IF (KX.NE.0) THEN
c           RKXPI= 3.14159265/FLOAT(KX)
c           DO 30 IX=1,KX
c               FACTOR=0.5*(1.0+COS(FLOAT(KX-IX+1)*RKXPI))
c               IXX=NX1-IX+1
c               DO 30 IY=1,NY1
c                   F(1,IX,IY)=F(1,IX,IY) * FACTOR
c               30 F(1,IXX,IY) =F(1,IXX,IY)* FACTOR
c           ENDIF
c
c           WRITE(25,150) KX, KY
c           write (25,*) kx,ky
c       endif
c
c.....center and ZERO OUT REMAINDER OF ARRAY
c
c       nxhalf=(nx-nx1)/2
c       nyhalf=(ny-ny1)/2
c       do i=1,nx1
c           do j=1,ny1
c               holdme(i,j)=f(1,i,j)
c           enddo
c       enddo
c       do i=1,nxhalf
c           do j=1,ny
c               f(1,i,j)=0.0
c           enddo
c       enddo
c       do i=nxhalf+1,nxhalf+nx1
c           do j=1,ny
c               if (j .le. nyhalf) f(1,i,j)=0.0
c               if (j.gt.nhalf .and. j.le.nhalf+ny1)
c                   f(1,i,j)=holdme(i-nxhalf,j-nyhalf)
c               if (j .gt. nyhalf+ny1) f(1,i,j)=0.0
c           enddo
c       enddo
c       do i=nxhalf+nx1+1,nx

```



```

        CALL WINDOW (NX,NY,XLAG,NWIND)
        CALL FFT2D (NX,NY,-1)
        ENDIF
    ENDIF

C.....WRITE FILTER (WAVENUMBER DOMAIN) ONTO UNIT 30 IF IOFIL = 1
C
C       IF (IOFIL.EQ.1) THEN
C           WRITE (30,*) NX,NY,IZERO,XMEAN
C           DO 200 IY=1,NY
C               WRITE (30,*) (H(IX,IY),IX=1,NX)
C200       CONTINUE
C           WRITE(6,1040) NX,NY
C       ENDIF
C
C       if (num .eq. 1) then
C           do 500 i=1,row
C               do 500 j=1,col
C                   xcdata(j,i) = xcdata(j,i)*h(j,i)
C500           continue
C       elseif (num .eq. 2) then
C           do 580 i=1,row
C               do 580 j=1,col
C                   ycdata(j,i) = ycdata(j,i)*h(j,i)
C580           continue
C       endif
C
C       return
C
C*****SUBROUTINE BNPDAS (CCUTLO,CCUTHI,NPASS,DELTA,NX,NY)
C*****SUBROUTINE BNPDAS (CCUTLO,CCUTHI,NPASS,DELTA,NX,NY)
C
C       "BNPDAS" CALCULATES TWO QUADRANTS OF THE WAVE# RESPONSE OF
C       AN IDEAL BANDPASS FILTER OF A (NX,NY) MATRIX.
C       ARRAY "H" MUST BE DIMENSIONED THE SAME AS IN THE MAIN PROGRAM
C
C       "CCUTLO"    LOWEST WAVE# TO BE PASSED, GE 0.0
C       "CCUTHI"    HIGHEST WAVE# TO BE PASSED, LE NYQUIST
C       "NPASS"     SWITCHES EITHER A PASS OR REJECTION BETWEEN
C                   "CUTLO" & "CUTHI"
C                   --1 REJECT WAVENUMBERS BETWEEN THE 2 WAVENUMBERS
C                   - 1 PASS  WAVENUMBERS BETWEEN THE 2 WAVENUMBERS
C       "DELTA"     DATA GRID INTERVAL, IN MAP UNITS
C       "NX"        NUMBER OF ROWS (POWER OF 2 GE "ICOL", 16,32,ETC)
C       "NY"        NUMBER OF ROWS (POWER OF 2 GE "IROW", 16,32,ETC)
C
C*****COMMON H(512,512)
C*****COMMON H,ZERO,ONE
C*****DIMENSION A(2)
C*****DATA A/4HPASS,4HCUT /
C
C       CUTHI=CCUTHI
C       CUTLO=CCUTLO
C       RCUTLO=999999.99
C       IF (CUTLO.GE. 0.0000001 ) RCUTLO= 1.0/CUTLO
C       RCUTHI=1.0/CUTHI
C       WAVLEN=2.0*DELTA
C       FNQ1=1.0/WAVLEN
C       WRITE (25,112) FNQ1,WAVLEN,CUTLO,RCUTLO,CUTHI,RCUTHI,NPASS
C
C       IF (IABS(NPASS).NE.1) THEN
C           WRITE (6,151)
C           STOP
C       ENDIF
C       IF (CUTHI.GT.FNQ1.OR.CUTHI.LE.CUTLO.OR.CUTLO.LT.0.0) THEN
C           WRITE (6,151)
C           STOP
C       ENDIF
C
C       NXX=NX+2
C       NX2=(NX/2)+1
C       NY2=(NY/2)+1
C       ANY2=FLOAT(NY2)
C       ZERO = (0.0,0.0)
C       ONE  = (1.0,0.0)
C       WAY  = A(1)
C
C       IF (NPASS.NE.1) THEN
C           ZERO = (1.0,0.0)
C           ONE  = (0.0,0.0)
C           WAY  = A(2)
C       ENDIF
C
C       RHIY2 = (FNQ1/(ANY2*CUTHI))**2

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```

NHIY = CUTHI*WAVLEN*ANY2+1.0
NHIY=AMINO(NHIY,NY2)
CLOWX=FLOAT(NX2)*WAVLEN*CUTLO
CHIX =FLOAT(NX2)*WAVLEN*CUTHI
C
  IF (CUTLO.LE.0.000001) THEN
    WRITE(6,152) WAY
    RLOWY2=0.0
    NLOWY=0
  ELSE
    IF (FNQ1-CUTHI.LT.0.00001) THEN
      WRITE(6,153) WAY
      RLOWY2=(FNQ1/(ANY2*CUTLO))**2
      NLOWY=CUTLO*WAVLEN*ANY2+1.0
    ELSE
      WRITE(6,154)
      RLOWY2=(FNQ1/(ANY2*CUTLO))**2
      NLOWY=CUTLO*WAVLEN*ANY2+1.0
    ENDIF
  ENDIF
C
C
C....."ZERO" OUT THE PART OF ARRAY TO BE ALTERED
C
  DO 35 IY=1,NY2
    DO 35 IX=1,NX
      H(IX,IY) = ZERO
35  CONTINUE
C
C.....OPERATE ON ROWS WHERE SOME WAVENUMBERS ARE .LE. CUTLO
C
  IF (NLOWY.NE.0) THEN
    MINS=1
    MAXS=NX2
    IF (NLOWY.EQ.1) THEN
      IF (CUTLO.GT.0.00001) MINS=NX2*CUTLO*WAVLEN+2.0001
      IF (FNQ1-CUTHI.GT.0.00001) MAXS=NX2*CUTHI*WAVLEN+1.0001
    ENDIF
    DO 102 IY=1,NLOWY
      Y2=FLOAT(IY-1)**2
      MINX=MINS
      IF (CUTLO.GT.0.000001) THEN
        MINX=CLOWX*SQRT(1.0-Y2*RLOWY2)+2.0001
      ENDIF
      MAXX=MAXS
      IF (FNQ1-CUTHI.GE.0.00001) THEN
        MAXX=CHIX*SQRT(1.0-Y2*RHIY2)+1.0001
      ENDIF
      IF (MINX.EQ.1) THEN
        H(1,IY) = ONE
        MINX=MINX+1
      ENDIF
      IF (MINX.LE.MAXX) THEN
        DO 150 IX=MINX,MAXX
          H(NXX-IX,IY) = ONE
        H(IX,IY) = ONE
150    ENDIF
102    CONTINUE
    ENDIF
C
C.....OPERATE ON ROWS WHERE ALL WAVENUMBERS ARE .GT. CUTLO
C
  IF (NHIY.NE.NY2) THEN
    LL=NLOWY+1
    DO 200 IY=LL,NHIY
      Y2=FLOAT(IY-1)**2
      MAXX=CHIX*SQRT(1.0-Y2*RHIY2)+1.0001
      H(1,IY) = ONE
      IF (MAXX.NE.1) THEN
        DO 180 IX=2,MAXX
          H(NXX-IX,IY) = ONE
        H(IX,IY) = ONE
180    ENDIF
200    CONTINUE
  ELSE
    IF (NLOWY+1.GT.NY2) RETURN
    LL=NLOWY+1
    DO 215 IY=LL,NY2
      DO 215 IX=1,NX
        H(IX,IY) = ONE
215    CONTINUE
  ENDIF
C
  RETURN
C
112  FORMAT(/1X,'NYQUIST WAVENUMBER = ',F10.5,'CYCLES PER DATA INTERVAL'
>           /1X,'NYQUIST WAVELENGTH = ',F10.5,' LENGTH INTERVALS'/
>           1X,'LOW WAVE# CUTOFF OF IDEAL FILTER = ',F10.5,
>           ' CYCLES PER DATA INTERVAL',3X,F15.5,' WAVELENGTH EQUIVALENT'/
>           1X,'HIGH WAVE# CUTOFF OF IDEAL FILTER = ',F10.5,

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>      ' CYCLES PER DATA INTERVAL',3X,F15.5,
>      ' WAVELENGTH EQUIVALENT',/1X,'NPASS= ',I1//)
151  FORMAT(5X,'IMPOSSIBLE FILTER CONSTRUCTION IS SPECIFIED. FATAL')
152  FORMAT(1H-, 'LOW ',A4,' FILTER IS BEING CONSTRUCTED IN "BNDPAS"')
153  FORMAT(1H-, 'HIGH ',A4,' FILTER IS BEING CONSTRUCTED IN "BNDPAS"')
154  FORMAT(1H-, 'BAND PASS FILTER IS BEING CONSTRUCTED IN "BNDPAS"')
C
C      END
C
C*****SUBROUTINE STORE (NNX,NNY)
C
COMMON H(512,512)
COMPLEX H
C
IF (NNY.EQ.1) RETURN
NX=NNX
NY=NNY
NXH=NX/2+1
NXX=NX+2
NYH=NY/2+2
NYL=NYH-1
DO 15 IY=NYH,NY
    NYL=NYL-1
    H(1,IY)=H(1,NYL)
    DO 10 IX=2,NX
        H(IX,IY)=CONJG (H(NXX-IX,NYL))
10    CONTINUE
    H(NXH,IY)=H(NXH,NYL)
15    CONTINUE
C
RETURN
END
C*****SUBROUTINE WINDOW (NX,NY,XLAG,NWIND)
C
C*****WINDOW" PERFORMS 2-DIMENSION WINDOWING OVER A 4 QUAD. DATA ARRAY *
C      EACH QUAD. IS SEPERATELY WINDOWED. THE 1.0 COEFFICIENT IS ALWAYS *
C      THE OUTER MOST CORNER OF THE ARRAY. *
C      FOR ONE DIMENSIONAL WINDOW, LET NY=1 *
C
C      "NX"      = NUMBER OF COLUMNS IN DATA MATRIX *
C      "NY"      = NUMBER OF ROWS IN DATA MATRIX *
C      "XLAG"    = SMOOTHING PARAMETER FOR WINDOWING IDEAL FILTER IN SPATIAL *
C                  DOMAIN. DETERMINES WHAT PERCENTAGE OF DATA IS WINDOWED *
C                  (NX*XLAG/100.0) THE REMAINDER IS SET TO 0.0. I.E. THE *
C                  SMALLER "XLAG" THE SMOOTHER THE WINDOWING. *
C      "XLAG"    MUST BE .GT. 0.0 AND. LE. 100.0 FOR WINDOWING *
C      VALUES OUTSIDE OF THIS RESULTS IN NO WINDOWING *
C      THE SMALLER THE "XLAG" THE SMOOTHER THE FILTER. *
C
C      "NWIND"  = TYPE OF WINDOW TO APPLY *
C                  -0 GIVES NO WINDOW *
C                  -1 gives a rectangular window *
C                  -2 GIVES BARTLETT WINDOW(TRIANGLE WINDOW) *
C                  -3 GIVES HAMMING-TUKEY WINDOW *
C                  -4 GIVES PARZEN WINDOW *
C
C*****COMMON H(512,512)
COMMON H(512,512)
COMPLEX H
C
IF (XLAG.LE.0.0 .OR. XLAG.GT.100.0) THEN
    WRITE(6,50) XLAG
    RETURN
ENDIF
C
LAG=FLOAT(NX)*XLAG/200.0+0.5
LAG=AMAX0(LAG,2)
PI=3.14159265
NXX=NX+2
NYY=NY+2
NX2=(NX/2)+1
XNMR=FLOAT(NX2)
XNX=1.0/FLOAT(NX2)
NY2=(NY/2)+1
IF (NY.EQ.1) NY2=1
NY=1.0/FLOAT(NY2)
C
RADIUS=FLOAT(LAG)*NXX
RADI=1.0/RADIUS
RAD2=RADIUS*RADIUS
NRAD=FLOAT(NY2)*RADIUS+1.0001
C

```

```

C.....APPLY RECTANGULAR WINDOW TO FILTER
C
C       IF (NWIND.EQ.1) THEN
C
C           IF (NRAD.NE.0) THEN
C               MAX=RADIUS*XNKR+1.0001
C
C               IF (MAX.EQ.0) THEN
C                   H(1,1)=(0.0,0.0)
C                   MAX=MAX+1
C               ENDIF
C
C               LL=MAX+1
C               DO 155 II=LL,NX2
C                   H(NXX-II,1)=(0.0,0.0)
C                   H(II,1)=(0.0,0.0)
C               ENDIF
C
C           IF (NRAD.NE.1.AND.NRAD.NE.0) THEN
C               DO 102 IY=2,NRAD
C                   IYY=NYY-IY
C                   YLEN2=(FLOAT(IY-1)*YNY)**2
C                   MAX=SQRT(RAD2-YLEN2)*XNKR+1.0001
C
C                   IF (MAX.EQ.0) THEN
C                       H(1,IY)=(0.0,0.0)
C                       H(IY,IYY)=(0.0,0.0)
C                       MAX=MAX+1
C                   ENDIF
C
C                   LL=MAX+1
C                   DO 105 II=LL,NX2
C                       H(NXX-II,IY)=(0.0,0.0)
C                       H(II,IY)=(0.0,0.0)
C                       H(NXX-II,IYY)=(0.0,0.0)
C                       H(II,IYY)=(0.0,0.0)
C               105 CONTINUE
C               102 CONTINUE
C           ENDIF
C
C           WRITE(25,660) XLAG,LAG
C           IF (NRAD.EQ.NY2) RETURN
C           LL=NRAD+1
C           DO 108 I=LL,NY2
C               IYY=NYY-I
C               H(1,I)=(0.0,0.0)
C               H(1,IYY)=(0.0,0.0)
C               DO 109 J=2,NX2
C                   H(J,I)=(0.0,0.0)
C                   H(NXX-J,I)=(0.0,0.0)
C                   H(J,IYY)=(0.0,0.0)
C               109 H(NXX-J,IYY)=(0.0,0.0)
C           108 CONTINUE
C
C.....APPLY BARTLETT WINDOW TO FILTER
C
C       ELSEIF (NWIND.EQ.2) THEN
C
C           IF (NRAD.NE.0) THEN
C               MAX=RADIUS*XNKR+1.0001
C
C               IF (MAX.GE.2) THEN
C                   DO 253 LL=2,MAX
C                       XI=FLOAT(LL-1)*XNX
C                       FACTOR=1.0-XI*RADI
C                       H(LL,1)=H(LL,1)*FACTOR
C                       MX=NXX-LL
C               253 H(MX,1)=H(MX,1)*FACTOR
C               ENDIF
C
C               LL=MAX+1
C               DO 255 II=LL,NX2
C                   H(NXX-II,1)=(0.0,0.0)
C               255 H(II,1)=(0.0,0.0)
C               ENDIF
C
C           IF (NRAD.NE.1.AND.NRAD.NE.0) THEN
C               DO 202 IY=2,NRAD
C                   IYY=NYY-IY
C                   XI=FLOAT(IY-1)*YNY
C                   YLEN2= XI*XI
C                   MAX=SQRT(RAD2-YLEN2)*XNKR+1.0001
C                   FACTOR=1.0-XI*RADI
C                   H(1,IYY)=H(1,IYY)*FACTOR
C                   H(1,IY)=H(1,IY)*FACTOR
C               202 IF (MAX.GE.2) THEN
C                   DO 203 LL=2,MAX
C                       XI=SQRT((FLOAT(LL-1)*XNX)**2+YLEN2)
C                       FACTOR=1.0-XI*RADI
C                       H(LL,IYY)=H(LL,IYY)*FACTOR
C                       H(LL,IY)=H(LL,IY)*FACTOR
C               203

```

```

        MX=NXX-LL
        H(MX,IYY)=H(MX,IYY)*FACTOR
        H(MX,IY)=H(MX,IY)*FACTOR
    ENDIF
C
    LL=MAX+1
    DO 205 II=LL,NX2
        H(NXX-II,IYY)=(0.0,0.0)
        H(II,IYY)=(0.0,0.0)
        H(NXX-II,IY)=(0.0,0.0)
    205    H(II,IY)=(0.0,0.0)
202    CONTINUE
    ENDIF
C
    WRITE(25,661) XLAG,LAG
    IF(NRAD.EQ.NY2) RETURN
    LL=NRAD+1
    DO 208 I=LL,NY2
        IYY=NYY-I
        H(1,I)=(0.0,0.0)
        H(1,IYY)=(0.0,0.0)
        DO 209 J=2,NX2
            H(J,IYY)=(0.0,0.0)
            H(NXX-J,IYY)=(0.0,0.0)
            H(J,I)=(0.0,0.0)
209    H(NXX-J,I)=(0.0,0.0)
208    CONTINUE
C.....APPLY HAMMING-TUKEY WINDOW TO FILTER
C
    ELSEIF(NWIND.EQ.3) THEN
C
        IF(NRAD.NE.0) THEN
            PIRADI=PI*RADI
            MAX=RADIUS*XNXR+1.0001
C
            IF(MAX.GE.2) THEN
                DO 353 LL=2,MAX
                    XI=FLOAT(LL-1)*XNX
                    FACTOR=0.5*(1.0+COS(PIRADI*XI))
                    H(LL,1)=H(LL,1)*FACTOR
                    MX=NXX-LL
353        H(MX,1)=H(MX,1)*FACTOR
                ENDIF
C
                LL=MAX+1
                DO 355 II=LL,NX2
                    H(NXX-II,1)=(0.0,0.0)
355        H(II,1)=(0.0,0.0)
                ENDIF
C
                IF(NRAD.NE.1.AND.NRAD.NE.0) THEN
                    DO 302 IY=2,NRAD
                        XI=FLOAT(IY-1)*YNY
                        YLEN2=XI*XI
                        IYY=NYY-IY
                        MAX=SQRT(RAD2-YLEN2)*XNXR+1.0001
                        FACTOR=0.5*(1.0+COS(PIRADI*XI))
                        H(1,IYY)=H(1,IYY)*FACTOR
                        H(1,IY)=H(1,IY)*FACTOR
C
                        IF(MAX.GE.2) THEN
                            DO 303 LL=2,MAX
                                XI=SQRT((FLOAT(LL-1)*XNX)**2+YLEN2)
                                FACTOR=0.5*(1.0+COS(PIRADI*XI))
                                H(LL,IYY)=H(LL,IYY)*FACTOR
                                H(LL,IY)=H(LL,IY)*FACTOR
                                MX=NXX-LL
                                H(MX,IYY)=H(MX,IYY)*FACTOR
                                H(MX,IY)=H(MX,IY)*FACTOR
                            ENDIF
C
                            LL=MAX+1
                            DO 305 II=LL,NX2
                                H(NXX-II,IYY)=(0.0,0.0)
                                H(II,IYY)=(0.0,0.0)
                                H(NXX-II,IY)=(0.0,0.0)
                            305    H(II,IY)=(0.0,0.0)
302    CONTINUE
                ENDIF
C
                WRITE(25,662) XLAG,LAG
                IF(NRAD.EQ.NY2) RETURN
                LL=NRAD+1
                DO 308 I=LL,NY2
                    IYY=NYY-I
                    H(1,I)=(0.0,0.0)
                    H(1,IYY)=(0.0,0.0)
                    DO 309 J=2,NX2
                        H(J,IYY)=(0.0,0.0)

```

```

        H(NXX-J, IYY)=(0.0,0.0)
        H(J,I)=(0.0,0.0)
309      H(NXX-J,I)=(0.0,0.0)
308      CONTINUE
C
C.....APPLY PARZEN WINDOW TO FILTER
C
C      ELSEIF (NWIND.EQ.4) THEN
C
C          IF (NRAD.NE.0) THEN
C              MAX=RADIUS*XNXR+1.0001
C              N2RAD=FLOAT(NY2)*RADIUS*0.5+1.0001
C              MAX2=SQRT(RAD2/4.0)*XNXR+1.0001
C              FACTOR=1.0-6.0*((XI*RADI)**2-(XI*RADI)**3)
C              H(1,1)=H(1,1)*FACTOR
C
C          IF (MAX2.GE.2) THEN
C              DO 453 LL=2,MAX2
C                  XI=FLOAT(LL-1)*XNX
C                  FACTOR=1.0-6.0*((XI*RADI)**2-(XI*RADI)**3)
C                  H(LL,1)=H(LL,1)*FACTOR
C                  MX=NXX-LL
C                  H(MX,1)=H(MX,1)*FACTOR
C              ENDIF
C
C          KOUNT=MAX2+1
C          DO 457 LL=KOUNT,MAX
C              XI=FLOAT(LL-1)*XNX
C              FACTOR=2.0*(1.0-(XI*RADI)**3)
C              H(LL,1)=H(LL,1)*FACTOR
C              MX=NXX-LL
C              H(MX,1)=H(MX,1)*FACTOR
C              LL=MAX+1
C              DO 455 II=LL,NX2
C                  H(NXX-II,1)=(0.0,0.0)
C                  H(II,1)=(0.0,0.0)
C              ENDIF
C
C          IF (NRAD.NE.1.AND.NRAD.NE.0) THEN
C              DO 402 IY=2,NRAD
C                  IYY=NYY-IY
C                  XI=FLOAT(IY-1)*YNY
C                  YLEN2=XI*X1
C                  MAX=SQRT(RAD2-YLEN2)*XNXR+1.0001
C                  N2RAD=FLOAT(NY2)*RADIUS*0.5+1.0001
C
C              IF (IY.GT.N2RAD) THEN
C                  KOUNT=2
C                  FACTOR=2.0*(1.0-(XI*RADI)**3)
C                  H(1,IYY)=H(1,IYY)*FACTOR
C                  H(1,IY)=H(1,IY)*FACTOR
C              ELSE
C                  MAX2=SQRT(RAD2/4.0-YLEN2)*XNXR+1.0001
C                  FACTOR=1.0-6.0*((XI*RADI)**2-(XI*RADI)**3)
C                  H(1,IYY)=H(1,IYY)*FACTOR
C                  H(1,IY)=H(1,IY)*FACTOR
C
C              IF (MAX2.GE.2) THEN
C                  DO 403 LL=2,MAX2
C                      XI=SQRT((FLOAT(LL-1)*XNX)**2+YLEN2)
C                      FACTOR=1.0-6.0*((XI*RADI)**2-(XI*RADI)**3)
C                      H(LL,IYY)=H(LL,IYY)*FACTOR
C                      H(LL,IY)=H(LL,IY)*FACTOR
C                      MX=NXX-LL
C                      H(MX,IYY)=H(MX,IYY)*FACTOR
C                      H(MX,IY)=H(MX,IY)*FACTOR
C                  ENDIF
C
C              KOUNT=MAX2+1
C              ENDIF
C
C              DO 407 LL=KOUNT,MAX
C                  XI=SQRT((FLOAT(LL-1)*XNX)**2+YLEN2)
C                  FACTOR=2.0*(1.0-(XI*RADI)**3)
C                  H(LL,IYY)=H(LL,IYY)*FACTOR
C                  H(LL,IY)=H(LL,IY)*FACTOR
C                  MX=NXX-LL
C                  H(MX,IYY)=H(MX,IYY)*FACTOR
C                  H(MX,IY)=H(MX,IY)*FACTOR
C                  LL=MAX+1
C                  DO 405 II=LL,NX2
C                      H(NXX-II,IYY)=(0.0,0.0)
C                      H(II,IYY)=(0.0,0.0)
C                      H(NXX-II,IY)=(0.0,0.0)
C                      H(II,IY)=(0.0,0.0)
C                  ENDIF
C
C              WRITE(25,663) XLAG,LAG
C              IF (NRAD.EQ.NY2) RETURN

```

```

LL=NRAD+1
DO 408 I=LL,NY2
  IYY=NYY-I
  H(1,I)=(0.0,0.0)
  H(1,IYY)=(0.0,0.0)
  DO 409 J=2,NX2
    H(J,IYY)=(0.0,0.0)
    H(NXX-J,IYY)=(0.0,0.0)
    H(J,I)=(0.0,0.0)
409   H(NXX-J,I)=(0.0,0.0)
408   CONTINUE
C
C.....DO NOT APPLY A WINDOW TO FILTER
C
C      ELSEIF (NWIND.EQ.0) THEN
C        WRITE (25,664)
C      ENDIF
C
C      RETURN
C
50   FORMAT (3X,'INPUTTED XLAG OF ',F5.2,' EXCEEDS PERMISSIBLE ',
>          ' RANGE OF GT. 0.0 .AND. .LE. 100.0, NO WINDOWING PERFORMED')
660  FORMAT ('RECTANGULAR WINDOW USED XLAG= ',F7.3,4X,'LAG= ',I5)
661  FORMAT ('BARTLETT WINDOW USED XLAG= ',F7.3,4X,'LAG= ',I5)
662  FORMAT ('HAMMING-TUKEY WINDOW USED XLAG= ',F7.3,4X,'LAG= ',I5)
663  FORMAT ('PARZEN WINDOW USED XLAG= ',F7.3,4X,'LAG= ',I5)
664  FORMAT ('NO WINDOWING HAS BEEN APPLIED ; XLAG= ',F7.3)
C
C      END
C
C
C      subroutine correlate(xpassno,ypassno)
integer xrow,xcol,yrow,ycol,nxout,nyout,
>      xpassno,ypassno,zerocnt(512,512),cnwind
real mincc,maxcc,ccwinout,prcnt,
>      pctr3,pctr4,minccin,maxccin,cxlag
complex h(512,512),power5,power6,totpwr
COMPLEX X(512,512),Y(512,512),zero,
>      POWER1,POWER2,POWER3,POWER4,XPOWER,TPOWER
REAL CCOEF,CCIN,CCOUT
DATA ZERO/(0.000000,0.000000)/
common /rowcol/ xrow,xcol,yrow,ycol
common /comps/ x,y
common /ccfit/ mincc,maxcc,minccin,maxccin,cnwind,cxlag
common /fftfifft/ nxout,nyout,prcnt,imean,fold,itypefold
common h
c
c----- subroutine description
c
c      correlate finds the correlation coefficient between each
c      wavenumber component of the two input arrays. each cc is
c      normalized to range between -1.0 through 0.0 to 1.0. the
c      cc is the cosine of the phase angle difference between
c      two wavenumber components.
c
c      revised 4 aug 90: i've added the windowing functions
c      available from the bandpassing subroutines to this cc-
c      filter. try them if you like.
c
c      updates 1 feb 91: change calculation of correlation
c      coefficient from a summation based formula to the cosine of
c      the phase angle difference.
c
c
nx=nxout
ny=nyout
c
if (xcol .ne. ycol .or. xrow .ne. yrow ) then
  write (*,*) 'NO MATCH BETWEEN ROW OR COLUMN'
  write (*,*) 'CORRELATION COEF MAY NOT BE CORRECT'
  write (*,*) 'PASSNUMBERS=',xpassno,ypassno
  write (*,*) 'FILE 1: ROW COL =',xrow,xcol
  write (*,*) 'FILE 2: ROW COL =',yrow,ycol
endif
c
pi=3.141592654
twopi=6.283185307
POWER1=ZERO
POWER2=ZERO
POWER3=ZERO
POWER4=ZERO
XPOWER=ZERO
TPOWER=ZERO
c
DO 110 j=1,NY
  DO 120 i=1,NX
c----- zerocnt array is a flagging array used to
c      set the windowing array h to equal
c      (0.0,0.0) or (1.0,0.0). a little inspection
c      of subroutine BNDPAS will help illuminate

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```

c           the principle.
c
c zerocnt(i,j)=1
c
c SUM THE POWERS & CROSS PRODUCTS OF THE INPUT MAPS.
c
c     POWER1=POWER1+(X(I,J)*CONJG(X(I,J)))
c     POWER2=POWER2+(Y(I,J)*CONJG(Y(I,J)))
c     XPOWER=XPOWER+(X(I,J)*CONJG(Y(I,J)))
c
c----- xrad is the phase angle of the x array wavenumber and
c yrad is the phase angle of the y array wavenumber. the
c cosine of the minimum phase difference is the correlation
c of the two wavenumbers. to find the minimum phase difference
c it is necessary to adjust xrad or yrad with integer values
c of pi. so....do not change the order of the if statements !!
c
c     xrad=atan(aimag(x(i,j))/(real(x(i,j))))
c     if (real(x(i,j)).lt.0.0) xrad=xrad+pi
c     if (aimag(x(i,j)).lt.0.0) xrad=xrad+twopi
c     yrad=atan(aimag(y(i,j))/(real(y(i,j))))
c     if (real(y(i,j)).lt.0.0) yrad=yrad+pi
c     if (aimag(y(i,j)).lt.0.0) yrad=yrad+twopi
c     delrad=abs(xrad-yrad)
c     ccoef=cos(delrad)
c
c     IF (CCOEF .GT. maxcc .or. CCOEF .LT. mincc) THEN
c         X(I,J)=ZERO
c         Y(I,J)=ZERO
c         zerocnt(i,j)=0
c     ENDIF
c
c SUM THE POWERS & CROSS PRODUCTS FOR THE OUTPUT MAPS.
c
c     POWER3=POWER3+(X(I,J)*CONJG(X(I,J)))
c     POWER4=POWER4+(Y(I,J)*CONJG(Y(I,J)))
c     TPOWER=TPOWER+(X(I,J)*CONJG(Y(I,J)))
c
120    CONTINUE
110    CONTINUE
c
c CALCULATE THE C.C. FOR THE INPUT MAPS.
c
c     if (power1 .eq. zero .or. power2 .eq. zero) then
c         write (*,*) 'power1 =',power1,xpassno
c         write (*,*) 'power2 =',power2,ypassno
c         ccin=9999.9
c     else
c         CCIN=REAL(XPOWER/SQRT(POWER1*POWER2))
c     endif
c
c CALCULATE THE C.C. FOR THE OUTPUT MAPS.
c
c     if (power3 .eq. zero .or. power4 .eq. zero) then
c         write (*,*) 'power3 =',power3,xpassno
c         write (*,*) 'power4 =',power4,ypassno
c         ccout=9999.9
c     else
c         CCOUT=REAL(TPOWER/SQRT(POWER3*POWER4))
c     endif
c
c CALCULATE THE PERCENTAGE OF THE POWER RETAINED IN THE FILTERED
c MAPS.
c
c     if (power1 .eq. zero .or. power2 .eq. zero) then
c         pctpr1=9999.9
c         pctpr2=9999.9
c     else
c         PCTPR1=(POWER3/POWER1)*100.0
c         PCTPR2=(POWER4/POWER2)*100.0
c     endif
c
c WRITE THE C.C. FOR THE INPUT & OUTPUT MAPS TO FILE 6.
c
c     WRITE (6,444) CCIN
c     WRITE (6,555) CCOUT
c
c WRITE THE POWER PERCENTAGES TO FILE 6.
c
c     WRITE (6,666) PCTPR1,PCTPR2
c 444  FORMAT (' ','THE CORRELATION COEFFICIENT BETWEEN THE INPUT '
c           *     ',MAPS IS ',F6.3)
c 555  FORMAT (' ','THE CORRELATION COEFFICIENT BETWEEN THE OUTPUT '
c           *     ',MAPS IS ',F6.3)
c 666  FORMAT (' ','THE PERCENTAGE OF THE TOTAL POWER IN MAP ONE',
c           *     ' PASSED IS ',F7.3,'%',/, ' THE PERCENTAGE OF THE TOTAL POWER',
c           *     ' IN MAP TWO PASSED IS ',F7.3,'%')
c
c     write (25,888) xpassno,ypassno,ccin,ccout,pctpr1,pctpr2
888  format (216,4f10.3)
c     if (ccin .lt. minccin) write (*,*)xpassno,ypassno,ccin,' <min'

```

```

      if (ccin .gt. maxccin) write (*,*)xpassno,ypassno,ccin,'>max'
c----- the following if statement controls
c----- the windowing functions for smoothing
c----- the output arrays and calculates a new
c----- output correlation coefficient and
c----- percents of power retained in the
c----- windowed arrays because
c----- the data will change slightly with
c----- windowing
c
c      write (*,*) '1 = zerocont, 0 != zerocont'
c      read (*,*) i
c      if (i .eq. 1) then
c          write (50,*) nx
c          write (50,*) ny
c          do i=1,ny
c              write (50,9970) (zerocont(j,i),j=1,nx)
c          enddo
c 9970      format (20(13,1x))
c      endif
c
c      if (cnwind .ge. 1 .and. cnwind .le. 4) then
c          power5=zero
c          power6=zero
c          totpwr=zero
c          do 300 i=1,ny
c              do 300 j=1,nx
c                  h(j,i)=(1.0,0.0)
c                  if (zerocont(j,i) .eq. 0) h(j,i)=(0.0,0.0)
c 300          continue
c          call store (nx,ny)
c          call fft2d (nx,ny,1)
c          call window (nx,ny,cxlag,cnwind)
c          call fft2d (nx,ny,-1)
c          do 330 iy=1,ny
c              do 330 ix=1,nx
c                  x(ix,iy)=x(ix,iy)*h(ix,iy)
c                  y(ix,iy)=y(ix,iy)*h(ix,iy)
c                  power5=power5+(x(ix,iy)*conjg(x(ix,iy)))
c                  power6=power6+(y(ix,iy)*conjg(y(ix,iy)))
c                  totpwr=totpwr+(x(ix,iy)*conjg(y(ix,iy)))
c 330          continue
c          if (power5 .eq. zero .or. power6 .eq. zero) then
c              write (*,*) 'power5 =',power5,xpassno
c              write (*,*) 'power6 =',power6,ypassno
c              ccwinout=9999.9
c              go to 340
c          endif
c          if (power1 .eq. zero .or. power2 .eq. zero) then
c              pctpr3=9999.9
c              pctpr4=9999.9
c              go to 340
c          endif
c          ccwinout=real(totpwr/sqrt(power5*power6))
c          pctpr3=(power5/power1)*100.0
c          pctpr4=(power6/power2)*100.0
c 340      continue
c          write (25,888) xpassno,ypassno,ccin,ccwinout,pctpr3,pctpr4
c 888      format (216,4f10.3)
c      endif
c
c      return
c
c
c      subroutine inverseft (num,mean,passno)
c      integer num,xrow,xcol,yrow,ycol,row,col,passno
c      real xdata(361,361),ydata(361,361),mean
c      complex xcdata(512,512),ycdata(512,512)
c      common /rowcol/ xrow,xcol,yrow,ycol
c      common /reals/ xdata,ydata
c      common /comps/ xcdata,ycdata
c      common /fftfifft/ nxout,nyout,prcnt,imean,fold,itypefold
c      COMMON H(512,512)
c      DIMENSION X(2,512,512),holdme(361,361)
c      COMPLEX H
c      EQUIVALENCE (X(1,1,1),H(1,1))
c
c      if (num .eq. 1) then
c          ny=nyout
c          nx=nxout
c          row=xrow
c          col=xcol
c          do 50 j=1,ny
c              do 50 i=1,nx
c                  h(i,j)=xcdata(i,j)
c              continue
c 50      elseif (num .eq. 2) then

```

```

      ny=nyout
      nx=nxout
      row=yrow
      col=ycol
      do 80 j=1,ny
        do 80 i=1,nx
          h(i,j) = ydata(i,j)
80      continue
      endif
c
c*****PROGRAM FRQ2SPA
c
c      PROGRAM FRQ2SPA INVERSE TRANSFORMS AN N X N MATRIX OF WAVENUMBER
c      DOMAIN COEFFICIENTS INTO THE N X N MATRIX OF SPACE DOMAIN
c      AMPLITUDES.  FUNCTIONS PERFORMED BY THIS PROGRAM INCLUDE :
c          - INVERSE TRANSFORM OF THE DATA
c          - RESTORING THE MEAN TO THE DATA
c          - CALCULATION OF SPACE DOMAIN MAXIMUM AND MINIMUM AMPLITUDES
c
c.....REQUIRED SUBROUTINES :
c
c      FFT2D, FORTK
c
c.....DIMENSIONING REQUIREMENTS :
c
c      X(2,N,N).....WHERE N IS THE NUMBER OF COLUMNS AND ROWS OF THE
c      H(N,N)      OUTPUT TRANSFORMED MATRIX.  N MUST BE AN INTEGRAL
c                  POWER OF TWO (2,4,8,256...).
c
c      NOTE : DIMENSIONS IN EVERY SUBROUTINE MUST BE
c      SET EQUAL TO DIMENSIONS IN MAIN PROGRAM.
c
c
c.....AUTHOR : JEFF LUCIUS
c              DEPARTMENT OF GEOLOGY AND MINERALOGY
c              OHIO STATE UNIVERSITY, DECEMBER 1984.
c
c      revised: 8 AUG 90
c      updated: 2 feb 91
c          added do loops that find the data portion of the
c          zero centered inverse transformed data.  a look at
c          subroutine datwnd will help figure this out.
c
c*****PROGRAM INVERSE TRANSFORM DATA TO THE SPACE DOMAIN
c
c      irow=row
c      icol=col
c
c      CALL FFT2D (NX,NY,+1)
c
c      nxhalf=(nx-ic平)/2
c      nyhalf=(ny-irow)/2
c      do i=nxhalf+1,nxhalf+ic平
c        do j=nyhalf+1,nyhalf+irow
c          holdme(i-nxhalf,j-nyhalf)=x(i,j)
c        enddo
c      enddo
c
c      total=0.0
c      DO 210 J=1,Irow
c        DO 210 I=1,ic平
c          x(i,j)=holdme(i,j)
c
c          total=total+x(i,j)
210      CONTINUE
c          xmean=total/float(ic平*irow)
c          IF (IMEAN .EQ. 1) THEN
c            do 215 j=1,irow
c              do 215 i=1,ic平
c                x(i,j)=x(i,j)+mean
c215      continue
c          ENDIF
c
c          XMIN= 1.0E20
c          XMAX=-1.0E20
c          DO 220 J=1,irow
c            if (num .eq. 1) then
c              do i=1,ic平
c                xdata(i,j) = x(i,j)
c              enddo
c            elseif (num .eq. 2) then
c              do i=1,ic平
c                ydata(i,j) = x(i,j)
c              enddo
c            endif
c          DO 220 I=1,ic平
c            XMIN=AMIN1(XMIN,X(i,j))

```

```

XMAX-AMAX1 (XMAX,X(1,I,J))
IF (XMAX.EQ.X(1,I,J)) THEN
  IMAX=I
  JMAX=J
ENDIF
IF (XMIN.EQ.X(1,I,J)) THEN
  IMIN=I
  JMIN=J
ENDIF
220  CONTINUE
c   WRITE(25,1020) XMAX, jMAX, iMAX, XMIN, jMIN, iMIN, xmean, passno
c   write (25,9980) passno, xmean, xmax, jmax, imax, xmin, jmin, imin
c   9980 format (15.2x,f13.5,2x,f13.5,2x,14,2x,i4,f13.5,2x,i4,2x,14)
c
1020 FORMAT('MAXIMUM OF IFFT = ',E15.7,' AT (',I3,',',I3,')/',
>           'MINIMUM = ',E15.7,' AT (',I3,',',I3,')/',
>           'MEAN AFTER IFFT = ',E15.7,' FOR PASS',i6,/)
c
c   return
c
c
c
c   subroutine STRKPAS (num)
integer num,xrow,xcol,yrow,ycol,spass,swind,
>           imean,nxout,nyout,row,col
real prcnt,slag
complex xcdata(512,512),ycdata(512,512)
common /fft1fft/ nxout,nyout,prcnt,imean,fold,itype,fold
common /comps/ xcdata,ycdata
common /striking/ angl,ang2,spass,swind,slag
COMMON H(512,512)
COMPLEX H
c
if (num .eq. 1) then
  row=nyout
  col=nkout
  nx=nxout
  ny=nyout
elseif (num .eq. 2) then
  row=nyout
  col=nxout
  nx=nxout
  ny=nyout
endif
c ****
c
c   "STRIKE" PERFORMS A STRIKE SENSITIVE FILTERING (FAN FILTER) *
c   ON UNIFORMLY GRIDDED ONE OR TWO DIMENSIONAL DATA SETS. *
c
c   "sPASS" - CONTROLS IF DATA IS TO BE PASSED OR REJECTED BETWEEN *
c   "ANG1" AND "ANG2".
c   = 1 PASS AZIMUTHS BETWEEN ANGLES "ANG1" & "ANG2" *
c   = -1 REJECT AZIMUTHS BETWEEN ANGLES "ANG1" & "ANG2" *
c   "ANG1" - SMALLEST ANGLE, GE 0.0 .AND. LT "ANG2"
c   "ANG2" - LARGEST ANGLE, GT "ANG1" .AND. LE 180.00 *
c
c
c   updates and revisions:
c
c   23 dec 91; added this strike pass routine to the fourier
c           program. required removal of write statements
c
c ****
c
c   CALL STRIKE (ANG1,ANG2,sPASS,NX,NY)
c
c----- CREATE SMOOTHED FILTER
c
IF (sLAG.gt.0.0 .and. sLAG.lt.100.0) then
  if (swind.gt.0 .and. swind.le.4) then
    CALL FFT2D (NX,NY,1)
    CALL WINDOW (NX,NY,SLAG,SWIND)
    CALL FFT2D (NX,NY,-1)
  endif
endif
c
c----- SET UP TO WRITE 30 if desired
c
c   DO 356 IY=1,NY
c   WRITE (30) (H(IX,IY),IX=1,NX)
c 356  CONTINUE
c
c----- ACCESS TRANSFORM OF DATA & MULTIPLY *FILTER (CONVOLVING)
c
if (num .eq. 1) then
  do 500 i=1,row
    do 500 j=1,col
      xcdata(j,i) = xcdata(j,i)*h(j,i)

```

```

500      continue
      elseif (num .eq. 2) then
        do 580 i=1,row
          do 580 j=1,col
            ycdatal(j,i) = ycdatal(j,i)*h(j,i)
580      continue
      endif
c      return
end
c
c      SUBROUTINE STRIKE (AANG1,AANG2,NNPASS,NNX,NNY)
c
c      COMPLEX H,ZERO,ONE
c      COMMON H(512,512)
c      DATA DG2RAD,DG90 /0.017453293,1.570796327/
c
c      ****
c      "STRIKE" CREATES A STRIKE SENSITIVE FILTER (FAN FILTER)      *
c      FOR 2 QUADRANTS OF THE (NX,NY) MATRIX                         *
c      ARRAY "H" MUST BE DIMENSIONED THE SAME AS IN THE MAIN PROGRAM  *
c
c      (ANGLES ARE MEASURED IN DEGREES CLOCKWISE FROM NORTH)      *
c      "ANG1" = SMALLEST ANGLE, GE 0.0 .AND. LT ANG2                *
c      "ANG2" = LARGEST ANGLE, GT ANG1 .AND. LE 180.0                 *
c      "NPASS" = STATES IF DATA IS PASSED OR REJECTED BETWEEN THE 2 ANGLES *
c                  --1 REJECT AZIMUTHS BETWEEN ANGLES "ANG1" & "ANG2"      *
c                  -1 PASS AZIMUTHS BETWEEN ANGLES "ANG1" & "ANG2"      *
c      "NX"      = NUMBER OF ROWS (POWER OF 2 GE "NX1", 16,32,ETC) MAX=128  *
c      "NY"      = NUMBER OF ROWS (POWER OF 2 GE "NY1", 16,32,ETC) MAX=128  *
c
c      ****
c
c      NX=NNX
c      NY=NNY
c      ANG1 = AANG1
c      ANG2 = AANG2
c      NPASS = NNPASS
c
c      IF(ANG1.LT.ANG2 .AND. ANG1.GE.0.0 .AND. ANG2.LE.180.0) GOTO 109
c          WRITE(6,125)
125      FORMAT(5X, 'ILLEGAL SPECIFICATION OF STRIKE ANGLES, FATAL')
          STOP
109  CONTINUE
c
c      NX2=NX/2+1
c      NY2=NY/2+1
c      NX1=NX+1
c      NXX=NX+2
c      NY2=NY+2
c      XY=FLOAT(NX2)/FLOAT(NY2)
c
c      ZERO= (0.0,0.0)
c      ONE = (1.0,0.0)
c      IF (NPASS.NE.-1) GOTO 160
c          ZERO=(1.0,0.0)
c          ONE =(0.0,0.0)
160  CONTINUE
c
c      ****
c      'ZERO' OUT ARRAY
c      ****
c
c      DO 15 IY=1,NY
c          DO 15 IX=1,NX
c              H(IX,IY)=ZERO
c
c      ****
c      COMPUTE PARAMETERS FOR SOUTHWEST QUADRANT OF MATRIX
c      ****
c
c      IF(ANG2.GE.90.0) GOTO 20
c          IYMAX=0
c          GOTO 200
c
c      20 IF(ANG1.GT.90.0) GOTO 114
c          A1=0.0
c          TA1=0.0
c          IYMAX=NY2
c          ADA1=1.5
c          GOTO 113
c
c      114 CONTINUE
c          A1=ATAN(TAN((ANG1-90.0)*DG2RAD)*XY)
c          TA1=TAN(A1)
c          IYMAX=FLOAT(NX2)/TA1+1.0
c          IYMAX=AMINO(IYMAX,NY2)
c          ADA1=1.0
c
c      113 CONTINUE
c

```

```

        IF (ANG2.LT.180.0) GOTO 115
        A2=DG90
        TA2=0.0
        ADA2=FLOAT (NX2)+0.5
        GOTO 116
115 CONTINUE
        A2=ATAN (TAN ((ANG2-90.0)*DG2RAD) *XY)
        TA2=TAN (A2)
        ADA2=1.0
116 CONTINUE
C
200 IF (ANG1.LE.90.0) GOTO 25
        IYMAXX=0
        GOTO 300
C ****
C      COMPUTE PARAMETERS FOR SOUTHEAST QUADRANT OF MATRIX
C ****
C
25 IF (ANG1.GT.0.0) GOTO 45
        A1=0.0
        TTA1=1.0E20
        ADDA1=FLOAT (NX2)-2.5
        GOTO 60
45 IF (ANG1.NE.90.0) GOTO 55
        A1=0.0
        A2=0.0
        TTA1=0.0
        TTA2=0.0
        ADDA1= 0.0
        ADDA2= 0.0
        IYMAXX=NY2
        GOTO 122
55 A1=ATAN (TAN (ANG1*D2RAD) /XY)
        TTA1= 1.0/TAN (A1)
        ADDA1=1.0
C
60 IF (ANG2.LT.90.0) GOTO 121
        IYMAXX=NY2
        TTA2=0.0
        ADDA2= 0.0
        GOTO 122
121 CONTINUE
        A2=ATAN (TAN (ANG2*D2RAD) /XY)
        TTA2= 1.0/TAN (A2)
        ADDA2=1.0
        IYMAXX= ABS (FLOAT (NX2) /TTA2+1.5)
        IYMAXX=AMINO (IYMAXX, NY2)
122 CONTINUE
C ****
C      CALCULATE THE FILTER COEFFICIENTS
C ****
C
300 NYMAX=AMAX0 (IYMAX, IYMAXX)
        DO 50 IY=1,NYMAX
        Y=FLOAT (IY-1)
C ****
C      DEFINE SOUTHWEST QUADRANT
C ****
C
        IF (IYMAX.LT.IY) GOTO 30
        MIN=Y*TA1+ADA1
        MAX=Y*TA2+ADA2
        MAX=AMINO (MAX, NX2)
C
        IF (MIN.GT.MAX) GOTO 30
        DO 75 IX=MIN,MAX
        H (IX,IY)=ONE
75
C ****
C      DEFINE SOUTHEAST QUADRANT
C ****
C
30        IF (IYMAXX.LT.IY) GOTO 35
        MIN=(NX1-(Y*TTA2))+ADDA2
        MIN=AMINO (MIN, NX)
        MAX=(NX1-(Y*TTA1))+ADDA1
        MAX=AMAX0 (MAX, NX2+1)
C
        IF (MAX.GT.NX) GO TO 35
        DO 275 IX=MAX,MIN
        H (IX,IY)=ONE
275
C ****
C      USE ANTI-SYMMETRY TO DEFINE QUADRANTS # 2 & 3
C ****
C
35        IF (IY.EQ.1 .OR. IY.EQ.NY2) GOTO 50

```

```

IYY=NNY-1Y
DO 40 IX=2,NX
    H(NXX-IX,IYY)=H(IX,IY)
    H(1,IYY)=H(1,IY)
40  CONTINUE
H(1,1)=(1.0,0.0)
C
RETURN
END
C
C
C
subroutine UPCON (num)
integer num,npass,imean,nwind,nfout,nyout,udnwind,
>           row,col
complex xcdata(512,512),ycdata(512,512)
common /fftfifft/ nfout,nyout,prcnt,imean,fold,itypefold
common /comps/ xcdata,ycdata
common /udcont/ delta,zcon,udxlag,udnwind
COMMON H(512,512)
COMPLEX H
C
if (num .eq. 1) then
    row=nyout
    col=nfout
    nx=nfout
    ny=nyout
elseif (num .eq. 2) then
    row=nyout
    col=nfout
    nx=nfout
    ny=nyout
endif
C ****
C
C "UPCON" PERFORMS UPWARD OR DOWNWARD CONTINUATION ON UNIFORMLY
C GRIDDED ONE OR TWO DIMENSIONAL DATA SETS.
C ****
C
C CREATE CONTINUATION FILTER
C
    CALL CONTIN (DELTA,ZCON,NX,NY)
    CALL STORE(NX,NY)
C
C smooth the continuation filter
C
IF (udXLAG.gt.0.0 .and. udXLAG.le.100.0) then
    if (udwind .le. 4 .and. udnwind .gt. 0) then
        CALL FFT2D (NX,NY,1)
        CALL WINDOW (NX,NY,udXLAG,udNWIND)
        CALL FFT2D (NX,NY,-1)
    endif
endif
C
C ACCESS TRANSFORM OF DATA & MULTIPLE *FILTER (CONVOLVING)
C
if (num .eq. 1) then
    do 500 i=1,row
        do 500 j=1,col
            xcdata(j,i) = xcdata(j,i)*h(j,i)
500     continue
elseif (num .eq. 2) then
    do 580 i=1,row
        do 580 j=1,col
            ycdata(j,i) = ycdata(j,i)*h(j,i)
580     continue
endif
C
return
end
C
C
C
SUBROUTINE CONTIN (DELTA,ZCON,NX,NY)
COMMON H(512,512)
COMPLEX H
C ****
C
C "CONTIN" COMPUTES TWO QUADRANTS (NX/2+1 BY NY) OF AN IDEA
C UPWARD OR DOWNWARD CONTINUATION FILTER DIMENSIONED "NX" BY "NY".
C
FOR ONE DIMENSION LET NY=1.
C
ARRAY "H" MUST BE DIMENSIONED THE SAME AS IN THE MAIN PROGRAM
C
C "DELTA"= GRID INTERVAL IN LENGTH UNITS
C "ZCON" = THE DEPTH OR HEIGHT AT WHICH CONTINUATION IS DESIRED.
C
    (IN THE SAME LENGTH UNITS AS "DELTA", I.E. MILES.KM)
C

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```

C      IF "ZCON" IS NEGATIVE FILTER WILL BE UPWARD CONTINUATION      *
C      IF "ZCON" IS POSITIVE FILTER WILL BE DOWNWARD CONTINUATION      *
C
C***** ****
C
C      PI2Z= 3.14159265 *ZCON/DELTA
C      NXX=NX+2
C      NX2=NX/2+1
C      RNX2=1.0/FLOAT(NX2)
C      NY2=NY/2+1
C      RNY2=1.0/FLOAT(NY2)
C
C      DO 101 IY=1,NY2
C          CON1=(FLOAT(IY-1)*RNY2)**2
C          S=SQRT(CON1)
C          X1=EXP(S*PI2Z)
C          H(1,IY)=CMPLX(X1,0.0)
C          DO 101 IX=2,NX2
C              S=SQRT((FLOAT(IX-1)*RNX2)**2+CON1)
C              X1=EXP(S*PI2Z)
C              H(IX,IY)=CMPLX(X1,0.0)
C              H(NXX-IX,IY)=H(IX,IY)
C 101  CONTINUE
C          H(1,1)=(1.0,0.0)
C
C      RETURN
C      END
C
C
C      subroutine DERIVA (num)
C      integer num,npass,imean,nwind,nxout,nyout,
C      >      row,col
C      complex xcdata(512,512),ycdata(512,512)
C      common /fftifft/ nxout,nyout,prcnt,imean,fold,itypefold
C      common /comps/ xcdata,ycdata
C      common /xyzderiv/ delta,nth,nway
C      COMMON H(512,512)
C      COMPLEX H
C
C      if (num .eq. 1) then
C          row=nyout
C          col=nxout
C          nx=nxout
C          ny=nyout
C      elseif (num .eq. 2) then
C          row=nyout
C          col=nxout
C          nx=nxout
C          ny=nyout
C      endif
C
C***** ****
C
C      "DERIVA" CALCULATES THE "NTH" DERIVATIVE IN THE WAVE*      *
C      DOMAIN OF UNIFORMLY GRIDDED ONE OR TWO DIMENSIONAL DATA SETS.  *
C
C***** ****
C
C      CREATE DERIVATIVE FILTER
C
C      CALL DERIV(NX,NY,NTH,NWAY,DELTA)
C
C      ACCESS TRANSFORM OF DATA  & MULTIPLE *FILTER (CONVOLVING)
C
C      if (num .eq. 1) then
C          do 500 i=1,row
C              do 500 j=1,col
C                  xcdata(j,i) = xcdata(j,i)*h(j,i)
C 500      continue
C      elseif (num .eq. 2) then
C          do 580 i=1,row
C              do 580 j=1,col
C                  ycdata(j,i) = ycdata(j,i)*h(j,i)
C 580      continue
C      endif
C
C      return
C      end
C
C
C      SUBROUTINE DERIV(NNX,NNY,NNTN,NWAY,DELTA)
C      COMMON C(512,512)
C      COMPLEX C,CON,CON2,CON3
C
C***** ****
C
C      "DERIV" CALCULATES THE VALUES OF 2 QUADRANTS FOR THE      *
C      "NTH" DERIVATIVE OF A (NX,NY) MATRIX. THESE VALUES ARE TO      *

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```

C BE MULTIPLIED BY THE WAVE# SPECTRUM OF THE GIVEN FIELD. *
C FOR A 1 DIMENSIONAL ARRAY SET "NY"=1 *
C ARRAY "C" MUST BE DIMENSIONED THE SAME AS IN THE MAIN PROGRAM. *
C *
C "NNTH" = THE ORDER OF DERIVATIVE DESIRED *
C "NWAY" = THE DIRECTION THE DERIVATIVE IS TO TAKEN *
C          0 VERTICAL DIRECTION *
C          1 HORIZONTAL DIRECTION (X) *
C          2 HORIZONTAL DIRECTION (Y) *
C "DELTA" = GRID INTERVAL IN LENGTH UNITS *
C *
C ****
C
C NX=NNX
C NY=NNY
C NTH=NNTH
C NXX=NN+2
C NX2=NN/2+1
C NYY=NN+2
C NY2=NN/2+1
C CON=(6.2831853,0.0)
C IF (NWAY.GE.1) CON=(0.0,6.2831853)
C RNXDEL=1.0/(FLOAT(NX)*DELTA)
C RNYDEL=1.0/(FLOAT(NY)*DELTA)
C
C ****
C TAKE VERTICAL DERIVATIVE IN WAVE# DOMAIN
C ****
C
C if (nway.eq.0) then
C   DO 105 IX=2,NX2
C     FX2=(FLOAT(IX-1)*RNXDEL)
C     C(IX,1)=(CON*FX2)**NTH
C 105   C(NXX-IX,1)=(CON*FX2)**NTH
C     C(1,1)=(0.0,0.0)
C
C   DO 110 IY=2,NY2
C     IYY=NYY-IY
C     FY2=(FLOAT(IY-1)*RNYDEL)
C     C(1,IYY)=(CON*FY2)**NTH
C     C(1,IY)=(CON*FY2)**NTH
C     FY2=FY2**2
C     DO 110 IX=2,NX2
C       FX2=(FLOAT(IX-1)*RNXDEL)**2
C       S=SQRT(FX2+FY2)
C       CON2=(CON+S)**NTH
C       C(NXX-IX,IYY)=CON2
C       C(IX,IYY)=CON2
C       C(NXX-IX,IY)=CON2
C 110   C(IX,IY)=CON2
C   RETURN
C
C ****
C TAKE HORIZONTAL(Y) DERIVATIVE IN WAVE# DOMAIN
C ****
C
C elseif (nway.eq.2) then
C   DO 205 IX=1,NX
C 205   C(IX,1)=(0.0,0.0)
C
C   DO 210 IY=2,NY2
C     IYY=NYY-IY
C     CON2=(FLOAT(IY-1)*RNYDEL*CON)**NTH
C     CON3=CONJG(CON2)
C     DO 210 IX=1,NX
C       C(IX,IYY)=CON3
C 210   C(IX,IY)=CON2
C   RETURN
C
C ****
C TAKE HORIZONTAL(X) DERIVATIVE IN WAVE# DOMAIN
C ****
C
C elseif (nway.eq.1) then
C   DO 305 IY=1,NY2
C     C(1,NYY-IY)=(0.0,0.0)
C 305   C(1,IY)=(0.0,0.0)
C
C   DO 310 IX=2,NX2
C     IXX=NXX-IX
C     CON2=(FLOAT(IX-1)*RNXDEL*CON)**NTH
C     CON3=CONJG(CON2)
C     C(IXX,1)=CON3
C     C(IX,1)=CON2
C     DO 310 IY=2,NY2
C       C(IXX,NYY-IY)=CON3
C       C(IXX,IY)=CON3
C       C(IX,NYY-IY)=CON2
C 310   C(IX,IY)=CON2
C   RETURN

```

```

      else
        write (*,*) 'nway is not equal to 0,1 or 2'
        stop
      endif
    c
    end
  c
  c
  c
  subroutine MAG2POL (num)
  integer num,npass,imean,nwind,nxout,nyout,
  >    row,col
  complex xcdata(512,512),ycdata(512,512)
  common /fftfift/ nxout,nyout,prcnt,imean,fold,itypefold
  common /comps/ xcdata,ycdata
  common /rtp/ azm,xinc,dec
  COMMON H(512,512)
  COMPLEX H
  c
  if (num .eq. 1) then
    row=nyout
    col=nxout
    nx=nxout
    ny=nyout
  elseif (num .eq. 2) then
    row=nyout
    col=nxout
    nx=nxout
    ny=nyout
  endif
  c
  ****
  C   "MAG2POL" APPROXIMATELY CALCULATES THE CORRESPONDING MAGNETIC   *
  C   ANOMALY MAP DUE TO AN EARTH'S FIELD VECTOR OF 0.0 DECLINATION,   *
  C   AND 90.0 INCLINATION FROM AN INPUTTED MAGNETIC ANOMALY MAP WITH   *
  C   A KNOWN FIELD VECTOR.
  c
  ****
  C   DEC-DEC+AZM
  CALL MAGPOL (XINC,DEC,NX,NY)
  C   ACCESS TRANSFORM OF DATA & MULTIPLE *FILTER (CONVOLVING)
  C
  if (num .eq. 1) then
    do 500 i=1,row
      do 500 j=1,col
        xcdata(j,i) = xcdata(j,i)*h(j,i)
  500   continue
  elseif (num .eq. 2) then
    do 580 i=1,row
      do 580 j=1,col
        ycdata(j,i) = ycdata(j,i)*h(j,i)
  580   continue
  endif
  c
  return
  end
  c
  c
  c
  subroutine MAGPOL (AINC,DDEC,NX,NY)
  COMMON X(512,512)
  COMPLEX X,CONA,CONB
  c
  ****
  C   "MAGPOL" CREATES A WAVE# REDUCTION-TO-MAGNETIC-POLE FILTER   *
  C   ONTO THE ARRAY "X" IN BLANK COMMON   *
  C   THE DIMENSIONS OF THE ARRAY "X" MUST BE IDENTICAL TO THAT IN   *
  C   THE MAIN PROGRAM.   *
  C   "AINC"      THE AVERAGE MAGNETIC INCLINATION OF THE AREA IN DEGREES.   *
  C   "DDEC"      THE AVERAGE MAGNETIC DECLINATION OF THE AREA IN DEGREES.   *
  c
  ****
  RR=3.14159265/180.0
  NX2=NX/2+1
  NX1=NX/2
  NXX=NX+2
  NY2=NY/2+1
  NY1=NY+2
  RNX=1.0/FLOAT(NX)
  RNY=1.0/FLOAT(NY)
  c
  SINI=SIN(AINC*RR)

```

```

COSI=COS (AINC*RR)
SIND=SIN (DDEC*RR)
COSD=COS (DDEC*RR)
C
CON3=COSI*COSD
CON2=COSI*SIND
C
CONA=1.0/CMPLX (SINI,CON2)**2
CONB=CONJG (CONA)
X(1,1)=(0.0,0.0)
DO 30 IX=2,NX1
   X (IX,1)=CONA
30 X (NX1-IX,1)=CONB
X (NX1,1)=CONA
C
CONA=1.0/CMPLX (SINI,CON3)**2
CONB=CONJG (CONA)
DO 50 IY=2,NY2
   IYY=NYY-IY
   FY=FLOAT (IY-1)*RNY
   FY2=FY*FY
   CFY=CON3*FY
   X (1,IYY)=CONB
   X (1,IY) =CONA
   DO 40 IX=2,NX1
      IXX=NXX-IX
      FX=FLOAT (IX-1)*RNX
      CON4=SQRT (FX**2+FY2)
      X (IXX,IY)=1.0/CMPLX (SINI, (CFY-FX*CON2)/CON4)**2
      X (IX,IYY)=CONJG (X (IXX,IY))
      X (IX,IY) =1.0/CMPLX (SINI, (FX*CON2+CFY)/CON4)**2
40   X (IXX,IYY)=CONJG (X (IX,IY))
      CON4=SQRT (0.25+FY2)
      X (NX2,IYY)=1.0/CMPLX (SINI, (0.5*CON2-CFY)/CON4)**2
      X (NX2,IY) =1.0/CMPLX (SINI, (0.5*CON2+CFY)/CON4)**2
C
      RETURN
end

```



```

program avgdifres
character*80 filename
integer coln,rown,colk,rowk,var,row,col,set
dimension dndata(550,550),dkdata(550,550),avgdata(550,550),
         difdata(550,550),ddata(550,550)
c
c----- program description
c   avgdifres is a bashing of matrix manipulation.  the program
c   will find the average of two input data sets, the difference
c   between them, and will resample (hence avg-dif-res aint science
c   great??) every other point, every third, fourth etc.. point.
c   if you want the average and difference of the input matrices
c   make sure you choose to resample every data point, ie choose
c   1 for 1x1.
c
c   write (*,*) '1 FOR ONE DATA SET'
c   write (*,*) '2 FOR TWO DATA SETS'
c   read (*,*) set
c
c   write (*,*) 'INPUT FILE OF DAWN GRIDDED ANOMALIES OR ONE DATA SET'
c   read (*,9990) filename
9990 format (a80)
open (10, file=filename,status='old',form='formatted')
if (set .eq. 1) go to 10
write (*,*) 'INPUT FILE OF DUSK GRIDDED ANOMALIES'
read (*,9990) filename
open (12, file=filename,status='old',form='formatted')
10 write (*,*) 'OUTPUT AVERAGED AND/OR RESAMPLED GRIDDED FILE'
read (*,9990) filename
open (20, file=filename,form='formatted')
if (set .eq. 1) go to 20
write (*,*) 'OUTPUT DIFFERENCE GRID OF (DUSK) - (DAWN)'
read (*,9990) filename
open (22, file=filename,form='formatted')
c
20 continue
write (*,*) 'RESAMPLE BY THIS NUMBER  USE:'
write (*,*) '1 for keeping the average grid as is'
write (*,*) '2 for 2 degrees by 2 degrees'
write (*,*) '3 for 3 degrees by 3 degrees  and so on'
read (*,*) var
c
read (10,*) coln
read (10,*) rown
read (10,*) xcolat
read (10,*) xlong
read (10,*) xgridspc
40 do 50 i=1,rown
      read (10,*) (dndata(i,j),j=1,coln)
50 continue
if (set .eq. 1) go to 170
read (12,*) colk
read (12,*) rowk
read (12,*) ycolat
read (12,*) ylong
read (12,*) ygridspc
80 do 100 i=1,rown
      read (12,*) (dkdata(i,j),j=1,colk)
100 continue
c
if (coln.ne.colk .or. rown.ne.rowk) then
  write (*,*) 'HEY NOW KIDS GRIDS ARE DIFFERENT SIZES'
  write (*,*) coln,rown,colk,rowk
  go to 999
endif
c
c----- find the average and difference matrices also
c----- calculate the total and average RMS difference.
totrms=0.0
do 150 i=1,rown
  do 150 j=1,coln
    avgdata(i,j)=((dndata(i,j)+dkdata(i,j))/2.0)
    difdata(i,j)=dkdata(i,j)-dndata(i,j)
    totrms=totrms+((sqrt((dndata(i,j)-dkdata(i,j))**2))/2.0)
150 continue
avgrms=totrms/(real(rown)*real(coln))
c
170 if (set .eq. 1) then
  do 180 i=1,rown
    do 180 j=1,coln
      avgdata(i,j)=dndata(i,j)
180 continue
endif
c
c----- this is the section that resamples
row=1
ii=1
200 jj=1
col=1
250 ddata(ii,jj)=avgdata(row,col)

```

```

col=col+var
if (col .gt. coln) go to 300
jj=jj+1
go to 250
300 row=row+var
if (row .gt. rown) go to 400
ii=ii+1
go to 200
400 continue
c
write (*,*) 'new rows=',ii,' new cols=',jj
write (20,*) jj
write (20,*) ii
write (20,*) xcolat
write (20,*) xlong
write (20,*) real(var)
do 450 k=1,ii
     write (20,9992) (ddata(k,l),l=1,jj)
450   continue
9992 format (6(f11.4,1x))
c
if (set .eq. 1) go to 999
write (22,*) coln
write (22,*) rown
write (22,*) ycolat
write (22,*) ylong
write (22,*) ygridspc
do 500 m=1,rown
     write (22,9992) (difdata(m,n),n=1,coln)
500   continue
write (*,*) 'total rms difference=',totrms
write (*,*) 'average rms difference=',avgrms
c
999 continue
close (10)
close (12)
close (20)
close (22)
stop
end

```

C-41

C-41

```

program sqrmag
character*80 filename
dimension xcore(100000),xxmag(100000),
>           core(361,361),xmag(361,361),xmultmag(400)

c----- program description
c   this program will find a least squares value of x that
c   can be multiplied by the difference matrix so that the
c   difference closer fits the dawn or dusk matrix. the
c   value of x is multiplied by the difference and subtracted
c   from the dawn or dusk grid to make an output grid.
c   NOTE: i realize i'm making the 2-D arrays
c         into 1-D arrays
c
c   write (*,*) 'input difference matrix'
c   read (*,9990) filename
9990 format (a80)
  open (10, file=filename,form='formatted',status='old')
  write (*,*) 'input dawn or dusk matrix of total field values'
  read (*,9990) filename
  open (11, file=filename,form='formatted',status='old')
  write (*,*) 'output (total field) - (x)(difference)'
  read (*,9990) filename
  open (20, file=filename,form='formatted')

c   cmean=0.0
c   fmean=0.0
  read (10,*) icol
  read (10,*) irow
  read (10,*) south
  read (10,*) west
  read (10,*) gridspc
  do i=1,irow
    read (10,*) (core(i,j),j=1,icol)
    do j=1,icol
      cmean=cmean+core(i,j)
    enddo
  enddo

c   read (11,*) imcol
  read (11,*) imrow
  read (11,*) south
  read (11,*) west
  read (11,*) gridspc
  do i=1,imrow
    read (11,*) (xmag(i,j),j=1,imcol)
    do j=1,imcol
      fmean=fmean+xmag(i,j)
    enddo
  enddo
  if (irow.ne.imrow .or. icol.ne.imcol ) then
    write (*,*) 'rows cor mag ',irow,imrow
    write (*,*) 'cols cor mag ',icol,imcol
    stop 10
  endif
  cmean=cmean/real(irow*icol)
  fmean=fmean/real(irow*icol)

c----- remove the mean values
  do 500 i=1,irow
    do 500 j=1,icol
      xmag(i,j)=xmag(i,j)-fmean
    core(i,j)=core(i,j)-cmean
500

c----- turn the 2-D arrays into 1-D (cheater)
  do i=1,irow
    do j=1,icol
      ii=((i-1)*icol)+j
      xxmag(ii)=xmag(i,j)
      xcore(ii)=core(i,j)
    enddo
  enddo

c----- find a scalar value of c transpose c
  ctc=0.0
  do 600 i=1,ii
600    ctc=(xcore(i)*xcore(i))+ctc

c----- find (c transpose c) inverse
  ctcinv=1.0/ctc
c
  ctf=0.0
  do 700 i=1,ii
700    ctf=(xcore(i)*xxmag(i))+ctf

c----- find x
  x=ctcinv*ctf
  write (*,*) 'the value of x = ', x

c   write (20,*) imcol
c   write (20,*) imrow
c   write (20,*) south

```

```
      write (20,*) west
      write (20,*) gridspc
      do i=1,irow
        do j=1,icol
          xmultmag(j)=xmag(i,j)-(x)*(core(i,j))
        enddo
        write (20,9991) (xmultmag(j),j=1,icol)
      enddo
      9991 format (6(f11.4,1x))
c
      999 continue
      stop
      end
```



```

program inversion
DIMENSION DW(3982),DP(3982),DFS(361,44)
COMMON XORD,YORD,DXD,DYD,NXD,NYD,RO,RD,E,G,COST,SINT,YC,THETA,PHI,
> P(3982),TMAG(3982),DF(361,44),S(7930153)
EQUIVALENCE (DW(1),P(1)), (DF(1),TMAG(1))
REAL I,INC(361),D,DEC(361),FLD(361),I1,D1,F1,myear,mi,md,
> m11,md1,mf1,mxoro,myoro,mdxo,mdyo,mlvo
real fldd,fldo,incd,inco,decd,deco
dimension fldd(44,181),fldo(44,361),incd(44,181),inco(44,361),
> decd(44,181),deco(44,361)
common /gmf/ fldd,fldo,incd,inco,decd,deco
character*80 filename
integer choice
C*****
C
C      PROGRAM NVERTSM CALCULATES A SET OF CGS-SUSCEPTIBILITIES FOR AN
C      NXD-BY-NYD SPHERICAL ARRAY OF POINT DIPOLES SUCH THAT THE RESUL-
C      TANT EQUIVALENT SOURCE FIELD IS A LEAST-SQUARES BEST FIT TO MAG-
C      NETIC DATA OBSERVED OVER AN NXO-BY-NYO SPHERICAL GRID.  OUTPUT
C      CONSISTS OF LISTINGS AND/OR PUNCHED DECKS OF EQUIVALENT SOURCE
C      SUSCEPTIBILITIES AND/OR ANOMALY VALUES (SEE DATA CARD 1 BELOW).
C
C      DIMENSIONING REQUIREMENTS.....
C      DIMENSION DW(NXD*NYD),DP(NXD*NYD),P(NXD*NYD),TMAG(NXD*NYD),
C      DF(NXO,NYO),S(NIJ) WHERE NIJ=(NXD*NYD)*(NXD*NYD+1)/2, FLD1(NXD),
C      INC1(NXD),D1(NXD),FLD(NXO),I(NXO),D(NYO)
C
C      this program has been slightly modified from a view point of
C      lines of code. these changes are all lower case. however from
C      the view point of run time it should now take less than 1/4 !!!
C      of the time that it took in the past. this is because no reads
C      from files 10 or 11 are necessary as all arrays are stored in
C      memory.
C
C      modifications made 15 may 90
C
C      further changes on 22 Sep 90
C          these changes are mostly removal of unnecessary write
C          statements and general cleanup of the program.
C
C      more changes on 2 Jan 91
C          this update included the addition of a few lines of code
C          that allows for input of a file of susceptibilities and
C          output of a magnetic field map.
C*****
C      DATA INPUT SEQUENCE *****
C
C      write (*,*) '0 IF YOU HAVE A FILE FOR THE VARIABLES'
C      write (*,*) '1 IF YOU WANT TO TYPE VARIABLES INTERACTIVELY'
C      read (*,*) choice
C      if (choice .eq. 0) go to 10
C      write (*,9991)
9991 format('NFLD=0 DO NOT CALCULATE EQUIVALENT SOURCE M-FIELD'/
> '      -1 CALCULATE EQUIVALENT SOURCE M-FIELD'/
> '      -2 GIVEN THE CGS-SUSCEPTIBILITIES THE PROGRAM'/
> '          WILL CALCULATE THE EQUIV SRC M-FLD'/
> '      NIO=0 DO NOT WRITE A FILE SUSCEPTIBILITIES'/
> '      -1 WRITE OUT A SEPARATE FILE OF SUSCEPTIBILITIES'/
> '      NFLD(1) NIO(0)')
C      read (*,*) nfld,nio
C
C      if (nfld .eq. 1) then
C          write (*,*) ''
C          write (*,*) 'the following refers to calculation of the',
C          'susceptibilities'
C          write (*,*) ''
C      endif
C      write (*,9992)
9992 format('NXO= NUMBER OF LONGITUDINAL COLS OF OBSERVATION GRID'/
> 'NYO= NUMBER OF LATITUDINAL ROWS OF OBSERVATION GRID'/
> 'XORO= WESTERN-MOST LONGITUDINAL COORDINATE OF OBSERVATION'/
> '      GRID IN -180.0 to 180.0 DEGREES'/
> 'YORO= SOUTHERN-MOST LATITUDINAL COORDINATE OF OBSERVATION'/
> '      GRID IN -90.0 to 90.0 DEGREES'/
> 'DXO= LONGITUDINAL STATION SPACING OF OBSERVATION GRID IN DEGS'/
> 'DYO= LATITUDINAL STATION SPACING OF OBSERVATION GRID IN DEGS'/
> 'ELVO= ELEVATION OF OBSERVATION GRID IN KILOMETERS (350.0) //'
> 'NXO NYO XORO YORO DXO DYO ELVO ')
C      read (*,*) nxo,nyo,xoro,yoro,dxo,dyo,elvo
C
C      write (*,9993)
9993 format ('NXD= NUMBER OF LONGITUDINAL COLS OF SOURCE GRID'/
> 'NYD= NUMBER OF LATITUDINAL ROWS OF SOURCE GRID'/
> 'XORD= WESTERN-MOST LONGITUDINAL COORDINATE OF SOURCE'/
> '      GRID IN -180.0 to 180.0 DEGREES'/
> 'YORD= SOUTHERN-MOST LATITUDINAL COORDINATE OF SOURCE'/
> '      GRID IN -90.0 to 90.0 DEGREES'/
> 'DXD= LONGITUDINAL STATION SPACING OF SOURCE GRID IN DEGREES'/
> 'DYD= LATITUDINAL STATION SPACING OF SOURCE GRID IN DEGREES'/

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>'ELVD= ELEVATION OF SOURCE GRID IN KILOMETERS (-50.0)'//
>'NXD NYD XORD YORD DxD DyD ELVD ')
read (*,*) nxd,nyd,xord,yord,dxd,dyd,elvd
c
  write (*,9994)
9994 format ('YEAR= EPOCH IN YEARS AND DECIMAL FRACTION YEARS'/
>' E.G., 1965.75 = 1 OCT 65 FOR WHICH THE'/
>' GEOMAGNETIC REFERENCE FIELD IS TO'/
>' BE COMPUTED AT SOURCE AND/OR OBSERVATION POINTS'/
>' - 0 USER SUPPLIES CHARACTERISTICS OF SOURCE POLARIZATION'/
>' FIELD (F1,II,D1) AND GEOMAGNETIC FIELD (I,D) OVER'/
>' OBSERVATION GRID'/
>'F1= SCALAR MAGNETIC INTENSITY IN GAMMAS OF SOURCE POLARIZATION'/
>' FIELD.'/
>'II= INCLINATION IN DEGREES OF SOURCE POLARIZING FIELD'/
>'D1= DECLINATION IN DEGREES OF SOURCE POLARIZING FIELD'//
>'NOTE---IF (F1+II+D1).EQ.0.0, THEN THE SOURCE POLARIZING'/
>' FIELD IS COMPUTED BY SUBROUTINE FIELDG FOR EPOCH'/
>' SPECIFIED BY THE YEAR-INPUT VARIABLE'//
>' YEAR (1980.0) F1 (0.0) II (0.0) D1 (0.0)')
read (*,*) year,f1,ii,d1
c
  write (*,9995)
9995 format ('I= INCLINATION IN DEGREES OF THE GEOMAGNETIC FIELD'/
>' OVER THE OBSERVATION POINTS'/
>'D= DECLINATION IN DEGREES OF THE GEOMAGNETIC FIELD OVER THE'/
>' OBSERVATION POINTS'//
>'NOTE---IF (I+D).EQ.0.0, THEN THE GEOMAGNETIC FIELD OVER THE'/
>' OBSERVATION POINT IS COMPUTED BY SUBROUTINE FIELDG'/
>' FOR THE EPOCH SPECIFIED BY THE YEAR-INPUT VARIABLE'//
>'I (0.0) D (0.0)')
read (*,*) i,d
write (*,*) 'ERROR FACTOR FOR VARIANCE (fak) (0.10E-7)'
read (*,*) fak
c
  if (nfld .eq. 0) go to 15
write (*,*) ' '
write (*,*) 'the following refers to calculation of the'
write (*,*) 'equivalent source magnetic field'
write (*,*) ' '
c
  write (*,9998)
9998 format('mnXO- NUMBER OF LONGITUDINAL COLS OF OBSERVATION GRID'/
>'mNYO- NUMBER OF LATITUDINAL ROWS OF OBSERVATION GRID'/
>'mXORO- WESTERN-MOST LONGITUDINAL COORDINATE OF OBSERVATION'/
>' GRID IN -180.0 to 180.0 DEGREES'/
>'mYORO- SOUTHERN-MOST LATITUDINAL COORDINATE OF OBSERVATION'/
>' GRID IN -90.0 to 90.0 DEGREES'/
>'mDXO- LONGITUDINAL STATION SPACING OF OBSERVATION GRID IN DEGS'/
>'mDYO- LATITUDINAL STATION SPACING OF OBSERVATION GRID IN DEGS'/
>'mELVO- ELEVATION OF OBSERVATION GRID IN KILOMETERS (350.0)'/
>'mnXO mNYO mXORO mYORO mDXO mDYO mELVO ')
read (*,*) mnxo,mnyo,mxoro,myoro,mdxo,mdyo,melvo
c
  write (*,9996)
9996 format ('mYEAR= EPOCH IN YEARS AND DECIMAL FRACTION YEARS'/
>' E.G., 1965.75 = 1 OCT 65 FOR WHICH THE'/
>' GEOMAGNETIC REFERENCE FIELD IS TO'/
>' BE COMPUTED AT SOURCE AND/OR OBSERVATION POINTS'/
>' - 0 USER SUPPLIES CHARACTERISTICS OF SOURCE POLARIZATION'/
>' FIELD (F1,II,D1) AND GEOMAGNETIC FIELD (I,D) OVER'/
>' OBSERVATION GRID'/
>'mF1= SCALAR MAGNETIC INTENSITY IN GAMMAS OF SOURCE POLARIZATION'/
>' FIELD.'/
>'mII= INCLINATION IN DEGREES OF SOURCE POLARIZING FIELD'/
>'mD1= DECLINATION IN DEGREES OF SOURCE POLARIZING FIELD'//
>'NOTE---IF (mF1+mII+mD1).EQ.0.0, THEN THE SOURCE POLARIZING'/
>' FIELD IS COMPUTED BY SUBROUTINE FIELDG FOR EPOCH'/
>' SPECIFIED BY THE YEAR-INPUT VARIABLE'//
>'mYEAR (0.0) mF1 (60000.0) mII (90.0) mD1 (0.0)')
read (*,*) myear,mf1,mii,mdl
c
  write (*,9997)
9997 format ('mI= INCLINATION IN DEGREES OF THE GEOMAGNETIC FIELD'/
>' OVER THE OBSERVATION POINTS'/
>'mD= DECLINATION IN DEGREES OF THE GEOMAGNETIC FIELD OVER THE'/
>' OBSERVATION POINTS'//
>'NOTE---IF (mI+mD).EQ.0.0, THEN THE GEOMAGNETIC FIELD OVER THE'/
>' OBSERVATION POINT IS COMPUTED BY SUBROUTINE FIELDG'/
>' FOR THE EPOCH SPECIFIED BY THE YEAR-INPUT VARIABLE'//
>'mI (90.0) mD (0.0)')
read (*,*) mi,md
write (*,*) '0 DO NOT SUBTRACT MEAN OF FINAL R-T-P MAP'
write (*,*) '1 SUBTRACT THE MEAN'
read (*,*) isub
go to 15
c
10  write (*,*) 'INPUT FILE OF NUMBERS FOR VARIABLES'
read (*,9990) filename
open (17, file=filename,status='old',form='formatted')

```

```

      READ (17,*) NFLD,NIO
      READ (17,*) NXO,NYO,XORO,YORO,DXO,DYO,ELVO
      READ (17,*) NXD,NYD,XORD,YORD,DXD,DYD,ELVD
      READ (17,*) YEAR,F1,I1,D1,I,D
      read (17,*) fak
      read (17,*) mnxo,mnyo,mxoro,myoro,mdxo,mdyo,mevlo
      read (17,*) myear,mfl,mil,mdl,mi,md
      read (17,*) isub
c
15   write (*,*) 'INPUT FILE OF GRIDDED ANOMALY DATA OR SUSC DATA'
      write (*,*) 'DATA SHOULD BE WEST TO EAST AND SOUTH TO NORTH'
c----- array df(ix, jy) reads the anomaly data
c           in gammas or nanoteslas with the input
c           starting with the southernmost latitude
c           at the westernmost longitude.
      read (*,9990) filename
9990 format (a80)
      open (13, file=filename,status='old',form='formatted')
      write (*,*) 'INPUT FILE OF SPHERICAL HARMONIC COEFFICIENTS'
      write (*,*) 'SUCH AS GSFC1283'
      read (*,9990) filename
      open (3, file=filename,status='old',form='formatted')
c      open (3, file='../../data/mgst1283',status='old',
c            >                                form='formatted')
      if (nfld .eq. 1 .or. nfld .eq. 2) then
         write (*,*) 'OUTPUT FILE OF EQUIVALENT SOURCE M-FIELD'
         read (*,9990) filename
         open (30, file=filename,form='formatted')
      endif
      if (nio .eq. 1) then
         write (*,*) 'OUTPUT FILE OF SUSCEPTIBILITIES'
         read (*,9990) filename
         open (33, file=filename,form='formatted')
      endif
      write (*,*) 'OUTPUT INFORMATION FILE OF A BUNCH OF STUFF!!!'
      read (*,9990) filename
      open (6, file=filename,form='formatted')
c
      if (nfld .eq. 2) go to 155
c
      WRITE(6,520) NXO,NYO,XORO,YORO,DXO,DYO,ELVO
      WRITE(6,540) NXD,NYD,XORD,YORD,DXD,DYD,ELVD
c
      IF (YEAR.LT.1.E-9) WRITE(6,420) F1,I1,D1,I,D
      IF (F1+I1+D1.LT.1.E-9.AND.I+D.GT.0.0) WRITE(6,430) YEAR,I,D
      IF (I+D.LT.1.E-9.AND.F1+I1+D1.GT.0.0) WRITE(6,440) YEAR,F1,I1,D1
      IF (I+D.LT.1.E-9.AND.F1+I1+D1.LT.1.E-9) WRITE(6,450) YEAR
c
c CALCULATE THE GEOMAGNETIC FIELD OVER THE SOURCE AND/OR OBSERVATION
c GRIDS, RESPECTIVELY
c
      IF (YEAR.LT.1.E-9) GO TO 120
      LQ=1
c
      CALL FIELDG (0.,0.,0.,0.,55,LQ,Q1,Q2,Q3,Q4)
c
      IF (F1+I1+D1.GT.0.0) GO TO 110
c
      CALL GEOMAG (YEAR,ELVD,YORD,XORD,DYD,DXD,NYD,NXD,11)
c
110 IF (I+D.GT.0.0) GO TO 120
c
      CALL GEOMAG (YEAR,ELVO,YORO,XORO,DYO,DXO,NYO,NXO,10)
c
120 CONTINUE
c
      read (13,*) iew
      read (13,*) ins
      read (13,*) scolat
      read (13,*) west
      read (13,*) gridspc
      DO 130 JY=1,NYO
         READ (13,*) (DF(IX,JY),IX=1,NXO)
130 continue
c
c COMPUTE MAXIMUM, MINIMUM AND AVERAGE AMPLITUDE VALUES FOR M-FIELD
c INPUT DATA
c
      DSUM=0.0
      DMIN=DF(1,1)
      DMAX=DMIN
      DO 140 JY=1,NYO
      DO 140 IX=1,NXO
         DSUM=DSUM+DF(IX,JY)
         IF (DMAX.LT.DF(IX,JY)) DMAX=DF(IX,JY)
         IF (DMIN.GT.DF(IX,JY)) DMIN=DF(IX,JY)
140 CONTINUE
      DSUM=DSUM/FLOAT(NXO*NYO)
      WRITE(6,640) DMAX,DMIN,DSUM
c

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```

c      save values for the reduction-to-pole
c
155 istrnxd=nxd
      istrnyd=nyd
      strxord=xord
      stryord=yord
      strdxd=dxd
      strdyd=dyd
      strlvd=lvd
      if (nfld .eq. 2) go to 840
c
c      CONVERT LAT AND LONG TO RADIAN AND ELEVATIONS TO EARTH RADII
c
c      PI=3.1415926536
      FACT=PI/180.0
c
      XORD=XORD*FACT
      YORD=YORD*FACT
      YORO=(90.0-YORD)*FACT
      YORD=(90.0-YORD)*FACT
      Dxo=Dxo*FACT
      DxD=DxD*FACT
      DyO=DyO*FACT
      DyD=DyD*FACT
c
      I=I*FACT
      D=D*FACT
      I1=I1*FACT
      D1=--D1*FACT
c
      REARTH=6371.0
      RO=ELVO+REARTH
      RD=ELVD+REARTH
      E=RD**2+RO**2
      G=2.0*RD*RO
      NP=(NxD*NYd)
      DO 150 JY=1,NP
          P(JY)=0.0
          DW(JY)=0.0
150  CONTINUE
c
      NIJ=NP*(NP+1)/2
      DO 160 JY=1,NIJ
160  S(JY)=0.0
c
c      COMPUTE WEIGHTING COEFFICIENTS, DW(L), L=1,NP
c
c      COMPUTE UPPER HALF OF SYMMETRIC A(TRANSPOSE)A MATRIX OF 1-ST ORDER
c      PARTIALS AND STORE AS 1-DIMENSIONAL ARRAY S(LLL), LLL=1,NIJ---I.E.
c      A(TRANSPOSE)A(I,J)=S(IJ), WHERE IJ=I*(I-1)/2+J
c
      IF (YEAR.LT.1.E-9) GO TO 180
      IF (F1+I1+D1.GT.0.0.AND.I+D.LT.1.E-9) GO TO 200
      IF (F1+I1+D1.LT.1.E-9.AND.I+D.GT.0.0) GO TO 220
c
c      COMPUTE A(TRANSPOSE)A MATRIX FOR CASE WHERE (I,D) AND (F1,I1,D1)
c      ARE DERIVED FROM FIELDG
c
      DO 170 JY=1,NYD
          THETA=YORO+(FLOAT(JY)-1.0)*DyO
          COST=COS(THETA)
          SINT=SIN(THETA)
c
          do 175 l=1,nx0
              fld(l)=fldo(jy,l)
              inc(l)=inco(jy,l)
              dec(l)=deco(jy,l)
175  continue
      DO 170 IX=1,NX0
          PHI=XORD+(FLOAT(IX)-1.0)*Dxo
          AI=INC(IX)
          AD=DEC(IX)
c
          CALL MAGS1 (AI,AD)
c
          DY=DF(IX,JY)-YC
          LLL=0
          DO 170 L=1,NP
              DW(L)=DW(L)+TMAG(L)*DY
          DO 170 K=1,L
              LLL=LLL+1
              S(LLL)=S(LLL)+TMAG(L)*TMAG(K)
170  CONTINUE
          GO TO 240
c
c      COMPUTE A(TRANSPOSE)A MATRIX FOR CASE WHERE USER SUPPLIES (I,D)
c      AND (F1,I1,D1)
c
180 DO 190 JY=1,NYD
      THETA=YORO+(FLOAT(JY)-1.0)*DyO

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      COST=COS (THETA)
      SINT=SIN (THETA)
      DO 190 IX=1,NXO
          PHI=XORO+(FLOAT(IX)-1.0)*DXO
C      CALL MAGS2 (I,D,F1,I1,D1)
C      DY=DF (IX,JY)-YC
C
C      LLL=0
      DO 190 L=1,NP
          DW(L)=DW(L)+TMAG (L)*DY
      DO 190 K=1,L
          LLL=LLL+1
          S(LLL)=S(LLL)+TMAG (L)*TMAG (K)
190  CONTINUE
      GO TO 240
C
C      COMPUTE A(TRANSPOSE)A MATRIX FOR CASE WHERE (I,D) ARE DERIVED
C      FROM FIELDG AND USER SUPPLIES (F1,I1,D1)
C
      200 DO 210 JY=1,NYO
          THETA=YORO+(FLOAT(JY)-1.0)*DYO
          COST=COS (THETA)
          SINT=SIN (THETA)
C
C      do 185 l=1,nxo
C          fld(l)=fldo(jy,l)
C          inc(l)=inco(jy,l)
C          dec(l)=deco(jy,l)
185   continue
C
      DO 210 IX=1,NXO
          PHI=XORO+(FLOAT(IX)-1.0)*DXO
          AI=INC (IX)
          AD=DEC (IX)
C
          CALL MAGS2 (AI,AD,F1,I1,D1)
C
          DY=DF (IX,JY)-YC
C
          LLL=0
          DO 210 L=1,NP
              DW(L)=DW(L)+TMAG (L)*DY
          DO 210 K=1,L
              LLL=LLL+1
              S(LLL)=S(LLL)+TMAG (L)*TMAG (K)
210  CONTINUE
      GO TO 240
C
C      COMPUTE A(TRANSPOSE)A MATRIX FOR CASE WHERE USER SUPPLIES (I,D)
C      AND (F1,I1,D1) ARE DERIVED FROM FIELDG
C
      220 DO 230 JY=1,NYO
          THETA=YORO+(FLOAT(JY)-1.0)*DYO
          COST=COS (THETA)
          SINT=SIN (THETA)
          DO 230 IX=1,NXO
              PHI=XORO+(FLOAT(IX)-1.0)*DXO
C
              CALL MAGS1 (I,D)
C
              DY=DF (IX,JY)-YC
              LLL=0
              DO 230 L=1,NP
                  DW(L)=DW(L)+TMAG (L)*DY
              DO 230 K=1,L
                  LLL=LLL+1
                  S(LLL)=S(LLL)+TMAG (L)*TMAG (K)
230  CONTINUE
240  CONTINUE
C----- if a transpose a without error
C----- variance is wanted then use
C----- write (20).
C     WRITE (20) (S(J),J=1,LLL)
C----- if a transpose observations without
C----- error variance is wanted then use
C----- write (25).
C     WRITE (25) (DW(L),L=1,NP)
C----- the following loop adds fak to the diagonal
C----- of aTa
C
      II=0
      DO 888 J=1,NP
          II=II+J
          S(II)=S(II)+FAK
888  CONTINUE
C
C      COMPUTE INVERSE OF S-ARRAY

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      CALL SPPCO (S,NP,RCOND,DP,INFO)
C
      WRITE (6,480) RCOND
      IF (INFO.NE.0) WRITE (6,490) INFO
      DO 250 IX=1,NP
      250 DP (IX)=DW (IX)
C
      CALL SPPSL (S,NP,DP)
C
C      WRITE OUT COORDINATE CHARACTERISTICS OF M-DIPOLES
C
      WRITE (6,590)
      L=0
      DO 260 JY=1,NYD
         YLAT=90.0-(YORD+FLOAT(JY-1)*DYD)/FACT
      DO 260 IX=1,NXD
         L=L+1
         XLON=(XORD+FLOAT(IX-1)*DXD)/FACT
         WRITE (6,600) DP (L),XLON,YLAT,ELVD
      260 CONTINUE
      DO 270 JY=1,NP
      270 P (JY)=DP (JY)
C
C      IF NIO = 1 WRITE SUSCEPTIBILITIES ONTO USER DEFINED UNIT 33
C
      if (nio .eq. 1) then
         write (33,*) iew
         write (33,*) ins
         write (33,*) scolat
         write (33,*) west
         write (33,*) gridspc
         IJK=1
         DO 375 JY=1,NYD
            IJK=IJK+NXD-1
            WRITE (33,'(4(E18.8,1X))') (DP (L),L=IJK,IJK1)
            IJK=IJK1+1
      375     CONTINUE
      endif
C
      IF (NFLD.eq.0) GO TO 410
      WRITE (6,620)
C
C      COMPUTE EQUIVALENT SOURCE M-FIELD
C
      840 continue
      WRITE (6,630)
      nxrd=istrnxrd
      nyd=istrnyd
      xord=strxord
      yord=stryord
      dxd=strdxrd
      dyd=strydyd
      elvd=strelvd
      if (fld .eq. 2) then
         read (13,*) iew
         read (13,*) ins
         read (13,*) scolat
         read (13,*) west
         read (13,*) gridspc
         do jy=1,nyd
            read (13,*) (df(ix,jy),ix=1,nxd)
         enddo
         DO JY=1,NYd
            do ix=1,nxd
               L=((jy-1)*nxrd)+ix
               P (L)=df (ix,jy)
            enddo
         enddo
      endif
C
      IF (mYEAR.LT.1.E-9) GO TO 880
      call fieldg (0.,0.,0.,55,1,q1,q2,q3,q4)
      if (mfl+ml+mdl .gt. 0.0) go to 870
      call geomag (myear,elvd,yord,xord,dyd,dxd,nyd,nxd,11)
      870 if (mi+md .gt. 0.0) go to 880
      call geomag (myear,mevlo,myoro,mxoro,mdxo,mnyo,mnxo,10)
C
      880 continue
C
      PI=3.1415926536
      FACT=PI/180.0
C
      mXORO=mXORO*FACT
      XORD=XORD*FACT
      mYORO=(90.0-mYORO)*FACT
      YORD=(90.0-YORD)*FACT
      mDXO=mDXO*FACT
      DXD=DXD*FACT
      mDYO=-mDYO*FACT
      DYD=-DYD*FACT

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C
mI=mI*FACT
mD=-mD*FACT
mI1=-mI1*FACT
mD1=-mD1*FACT
C
REARTH=6371.0
RO=RELVO+REARTH
RD=ELVD+REARTH
E=RD**2+RO**2
G=2.0*RD*RO
C
IF (mYEAR.LT.1.E-9) GO TO 300
IF (mF1+mI1+mD1.GT.0.0 .AND. mI+mD.LT.1.E-9) GO TO 330
IF (mF1+mI1+mD1.LT.1.E-9 .AND. mI+mD.GT.0.0) GO TO 360
C
COMPUTE M-FIELD FOR CASE WHERE (mI,mD) AND (mF1,mI1,mD1)
C
ARE DERIVED FROM FIELDG
C
DO 290 JY=1,mNYO
    THETA=mYORO+(FLOAT(JY)-1.0)*mDYO
    COST=COS(THETA)
    SINT=SIN(THETA)
C
    do 195 l=1,mNKO
        fld(l)=fldo(jy,l)
        inc(l)=inco(jy,l)
        dec(l)=deco(jy,l)
195    continue
C
    DO 280 IX=1,mNKO
        PHI=mXORO+(FLOAT(IX)-1.0)*mDXO
        aI=INC(IX)
        aD=DEC(IX)
C
        CALL MAGS1 (aI,aD)
C
280    DFS(IX,JY)=YC
290    WRITE(6,580) (DFS(IX,JY),IX=1,mNKO)
    GO TO 390
C
COMPUTE M-FIELD FOR CASE WHERE USER SUPPLIES (mI,mD)
C
AND (mF1,mI1,mD1)
C
300 DO 320 JY=1,mNYO
    THETA=mYORO+(FLOAT(JY)-1.0)*mDYO
    COST=COS(THETA)
    SINT=SIN(THETA)
    DO 310 IX=1,mNKO
        PHI=mXORO+(FLOAT(IX)-1.0)*mDXO
C
        CALL MAGS2 (mI,mD,mF1,mI1,mD1)
C
310    DFS(IX,JY)=YC
320    WRITE(6,580) (DFS(IX,JY),IX=1,mNKO)
    GO TO 390
C
COMPUTE M-FIELD FOR CASE WHERE (mI,mD) ARE DERIVED FROM
C
FIELDG AND USER SUPPLIES (mF1,mI1,mD1)
C
330 DO 350 JY=1,mNYO
    THETA=mYORO+(FLOAT(JY)-1.0)*mDYO
    COST=COS(THETA)
    SINT=SIN(THETA)
C
    do 205 l=1,mNKO
        fld(l)=fldo(jy,l)
        inc(l)=inco(jy,l)
        dec(l)=deco(jy,l)
205    continue
C
    DO 340 IX=1,mNKO
        PHI=mXORO+(FLOAT(IX)-1.0)*mDXO
        aI=INC(IX)
        aD=DEC(IX)
C
        CALL MAGS2 (aI,aD,mF1,mI1,mD1)
C
340    DFS(IX,JY)=YC
350    WRITE(6,580) (DFS(IX,JY),IX=1,mNKO)
    GO TO 390
C
COMPUTE M-FIELD FOR CASE WHERE USER SUPPLIES (mI,mD) AND
C
(mF1,mI1,mD1) ARE DERIVED FROM FIELDG
C
360 DO 380 JY=1,mNYO
    THETA=mYORO+(FLOAT(JY)-1.0)*mDYO
    COST=COS(THETA)
    SINT=SIN(THETA)
    DO 370 IX=1,mNKO
        PHI=mXORO+(FLOAT(IX)-1.0)*mDXO

```

```

C
      CALL MAGS1 (mI,mD)
C
 370      DFS(IX,JY)=YC
 380      WRITE(6,580) (DFS(IX,JY),IX=1,mNKO)
 390      CONTINUE
C
C      COMPUTE MAXIMUM, MINIMUM AND AVERAGE AMPLITUDE VALUES FOR EQUIVA-
C      LENT SOURCE M-FIELD
C
  DSUM=0.0
  DMIN=DFS(1,1)
  DMAX=DMIN
  DO 400 JY=1,mNYO
  DO 400 IX=1,mNKO
    DSUM=DSUM+DFS(IX,JY)
    IF (DMAX.LT.DFS(IX,JY)) DMAX=DFS(IX,JY)
    IF (DMIN.GT.DFS(IX,JY)) DMIN=DFS(IX,JY)
 400 CONTINUE
  DSUM=DSUM/FLOAT(mNKO*mNYO)
  WRITE(6,640) DMAX,DMIN,DSUM
C
  if (isub .eq. 0) dsum=0.0
  dmax=dfs(1,1)
  dmin=dmax
  write (30,*) mnko
  write (30,*) mnyo
  write (30,*) myoro/fact
  write (30,*) mxoro/fact
  write (30,*) mdxo/fact
  DO 385 JY=1,mNYO
    WRITE(30,580) ((DFS(IX,JY)-dsum),IX=1,mNKO)
    do 385 ix=1,mnko
      dmax=max(dmax,(dfs(ix,jy)-dsum))
      dmin=min(dmin,(dfs(ix,jy)-dsum))
 385 CONTINUE
  if (isub .eq. 1) write (6,*) 'new max=',dmax,' new min=',dmin
C
  410 CONTINUE
  SSUM=0.0
  DO 900 II=1,mNKO
    DO 900 J=1,mNYO
      SSUM=SSUM+ (DF(II,J)-DFS(II,J))**2
 900 CONTINUE
  WRITE(6,790) SSUM
 790 FORMAT(' SUM OF SQUARES = ',E15.10)
 901 CONTINUE
  STOP
C
 420 FORMAT (/,1X,3HF1=,F10.3,5X,3HI1=,F6.2,5X,3HD1=,F6.2,5X,2HI=,F6.2,
 15X,2HD=,F6.2,/ )
 430 FORMAT (/,1X,5HYEAR=,F10.5,5X,2HI=,F6.2,5X,2HD=,F6.2,/ )
 440 FORMAT (/,1X,5HYEAR=,F10.5,5X,3HF1=,F10.3,5X,3HI1=,F6.2,5X,3HD1=,F
16.2,/ )
 450 FORMAT (/,1X,5HYEAR=,F10.5,/ )
 480 FORMAT (//,2X, 7HRCOND =,E20.8)
 490 FORMAT (//,2X,26HATA LEADING MINOR OF ORDER, I5,1X,24HIS NOT POSITI
1VE DEFINITE)
 520 FORMAT (2X,4HNKO=,I5,5X,4HNYO=,I5,5X,5HXORO=,F10.5,5X,5HYORO=,F10.
15,5X,4HDXO=,F10.5,5X,4HDYO=,F10.5,5X,5HEIVO=,F10.5,//)
 540 FORMAT (2X,4HNXD=,I5,5X,4HNYD=,I5,5X,5HXORD=,F10.5,5X,5HYORD=,F10.
15,5X,4HDXD=,F10.5,5X,4HDYD=,F10.5,5X,5HEIVD=,F10.5,//)
 580 FORMAT (8(1X,F9.3))
 590 FORMAT (//,'CGS-SUSCEPTIBILITIES',5X,'E-LONGITUDE',5X,'N-',
>'LATITUDE',5X,'KM-ELEVATION',/ )
 600 FORMAT (1X,E20.5,5X,F10.4,5X,F10.4,5X,F10.4)
 620 FORMAT (///)
 630 FORMAT (//,2X,25HEQUIVALENT SOURCE M-FIELD,/)
 640 FORMAT (//,2X,5HDMAX=,F10.3,10X,5HDMIN=,F10.3,10X,5HDAVG=,F10.3)
C
  END
  SUBROUTINE MAGS1 (I,D)
C*****
C***** SUBROUTINE MAGS1 CALCULATES THE TOTAL MAGNETIC FIELD AT A SPHERICAL
C***** OBSERVATION POINT (R,THETA,PHI) DUE TO A SPHERICAL ARRAY OF POINT
C***** DIPOLES WITH CGS-SUSCEPTIBILITIES P(L) AT SOURCE GRID COORDINATES
C***** (R1,THETA1,PHI1). POLARIZING FIELD CHARACTERISTICS (F1,I1,D1)
C***** ARE READ FROM TAPE11.
C*****
C
  COMMON XORD,YORD,DXD,DYD,NXD,NYD,RO,RD,E,G,COST,SINT,YC,THETA,PHI,
>P(3982),TMAG(3982),D(361,44),S(7930153)
  real f1dd,f1do,incd,inco,decd,deco
  dimension f1dd(44,181),f1do(44,361),incd(44,181),inco(44,361),
>          decd(44,181),deco(44,361)
  common /gmf/f1dd,f1do,incd,inco,decd,deco
  REAL I,I1,JR,JTHETA,JPHI,INC1(181),FLD1(181),DEC1(181)
  YC=0.0
  L=0

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DO 110 JY=1,NYD
  THETAI=YORD+FLOAT(JY-1)*DYD
  COST1=COS(THETAI)
  SIN1=SIN(THETAI)
  CT1T=COST1*COST
  ST1T=SINT1*SINT
  SC1T=SINT1*COST
  CS1T=COST1*SINT
C
C      do 730 k=1,nxd
C          fld1(k)=fldd(jy,k)
C          incl(k)=incd(jy,k)
C          decl(k)=decd(jy,k)
C      continue
C
 730  DO 110 IX=1,NXD
        L=L+1
C
C      COMPUTE POINT DIPOLE POLARIZATION VECTOR IN SPHERICAL ORTHONORMAL
C      UNIT VECTORS (ER,ETHETA,EPHI) WITH SUCEP(L)=1.0
C
C      F1=FLD1(IX)
C      I1=INC1(IX)
C      D1=DEC1(IX)
C
C      JR=F1*SIN(I1)
C      JTHETA=F1*COS(I1)*COS(D1)
C      JPHI=F1*COS(I1)*SIN(D1)
C
C      COMPUTE MAGNETIC FIELD VECTOR (U,V,W) AT THE POINT (R,THETA,PHI)
C      DUE TO POINT DIPOLES AT (R1,THETAI(JY),PHI1(IX))
C
C      PHI1=XORD+FLOAT(IX-1)*DXD
C      SINP=SIN(PHI-PHI1)
C      COSP=COS(PHI-PHI1)
C      A=CT1T+ST1T*COSP
C      B=SC1T-CS1T*COSP
C      C=SINT1*SINP
C      R2=E-G*A
C      R15=R2**1.5
C      R25=R2**2.5
C      XX=JR*(RD-RO*A)+JTHETA*RO*B-JPHI*RO*C
C      ATHETA=-CS1T+SC1T*COSP
C      BTHERA=-ST1T-CT1T*COSP
C      CTHETA=COST*SINP
C      APHI=-SINT1*SINP
C      BPHI=COST1*SINP
C      CPHI=COSP
C
C      U1=-JR*A+JTHETA*B-JPHI*C
C      U2=-3.0*XX*(RO-RD*A)
C      U3=U1/R15
C      U4=U2/R25
C      U=U3+U4
C
C      V1=-JR*ATHETA+JTHETA*BTHERA-JPHI*CTHETA
C      V2=-3.0*XX*RD*ATHETA
C      V3=V1/R15
C      V4=V2/R25
C      V=V3+V4
C
C      W1=-JR*APHI+JTHETA*BPHI-JPHI*CPHI
C      W2=3.0*XX*RD*APHI
C      W3=W1/R15
C      W4=W2/R25
C      W=W3+W4
C
C      CALCULATE THE COMPONENT OF THE ANOMALOUS FIELD IN THE DIRECTION
C      OF THE GEOMAGNETIC FIELD AT THE OBSERVATION POINT---I.E.,
C      ((U,V,W)*(UR,UTHETA,UPHI))*P(L) = TOTAL MAGNETIC FIELD
C
C      UR=SIN(I)
C      UTHETA=COS(I)*COS(D)
C      UPHI=COS(I)*SIN(D)
C
C      TMAG(L)=UR*U+UTHETA*V+UPHI*W
C      YC=YC+P(L)*TMAG(L)
110  CONTINUE
C
C      RETURN
C
C      END
C      SUBROUTINE MAGS2 (I,D,F1,I1,D1)
C
C*****SUBROUTINE MAGS2 CALCULATES THE TOTAL MAGNETIC FIELD AT A SPHERICAL
C*****OBSERVATION POINT (R,THETA,PHI) DUE TO A SPHERICAL ARRAY OF POINT
C*****DIPOLES WITH CGS-SUSCEPTIBILITIES P(L) AT SOURCE GRID COORDINATES
C***** (R1,THETAI,PHI1).
C*****

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C
COMMON XORD,YORD,DXD,DYD,NXD,NYD,RO,RD,E,G,COST,SINT,YC,THETA,PHI,
>P(3982),TMAG(3982),DF(361,44),S(7930153)
REAL I,I1,JR,THETA,PHI
YC=0.0
L=0
DO 110 JY=1,NYD
  THETA1=YORD+FLOAT(JY-1)*DYD
  COST1=COS(THETA1)
  SINT1=SIN(THETA1)
  CT1T=COST1*COST
  ST1T=SINT1*SINT
  SC1T=SINT1*COST
  CS1T=COST1*SINT
C
  DO 110 IX=1,NXD
    L=L+1
C
C COMPUTE POINT DIPOLE POLARIZATION VECTOR IN SPHERICAL ORTHONORMAL
C UNIT VECTORS (ER,ETHETA,EPHI) WITH SUSCEP(L)=1.0
C
    JR=F1*SIN(I1)
    JTHETA=F1*COS(I1)*COS(D1)
    JPHI=F1*COS(I1)*SIN(D1)
C
C COMPUTE MAGNETIC FIELD VECTOR (U,V,W) AT THE POINT (R,THETA,PHI)
C DUE TO POINT DIPOLES AT (R1,THETA1(JY),PHI1(IX))
C
    PHI1=XORD+FLOAT(IX-1)*DXD
    SINP=SIN(PHI-PHI1)
    COSP=COS(PHI-PHI1)
    A=CT1T*ST1T*COSP
    B=SC1T-CS1T*COSP
    C=SINT*SINP
    R2=E-G*A
    R15=R2**1.5
    R25=R2**2.5
    XX=JR*(RD-RO*A)+JTHETA*RO*B-JPHI*RO*C
    ATHETA=-CS1T+SC1T*COSP
    BTHETA=-ST1T-CT1T*COSP
    CTHETA=COST*SINP
    APHI=-SINT1*SINP
    BPHI=COST1*SINP
    CPHI=COSP
C
    U1=-JR*A+JTHETA*B-JPHI*C
    U2=-3.0*XX*(RO-RD*A)
    U3=U1/R15
    U4=U2/R25
    U=U3+U4
C
    V1=-JR*ATHETA+JTHETA*BTHETA-JPHI*CTHETA
    V2=3.0*XX*RD*ATHETA
    V3=V1/R15
    V4=V2/R25
    V=V3+V4
C
    W1=-JR*APHI+JTHETA*BPHI-JPHI*CPHI
    W2=3.0*XX*RD*APHI
    W3=W1/R15
    W4=W2/R25
    W=W3+W4
C
C CALCULATE THE COMPONENT OF THE ANOMALOUS FIELD IN THE DIRECTION
C OF THE GEOMAGNETIC FIELD AT THE OBSERVATION POINT---I.E.,
C ((U,V,W)*(UR,UTHETA,UPHI))*P(L) = TOTAL MAGNETIC FIELD
C
    UR=SIN(I)
    UTHETA=COS(I)*COS(D)
    UPHI=COS(I)*SIN(D)
C
    TMAG(L)=UR*U+UTHETA*V+UPHI*W
    YC=YC+P(L)*TMAG(L)
110 CONTINUE
C
C      RETURN
C
END
SUBROUTINE GEOMAG (YEAR,ELV,THETA,PHI,HTHETA,HPHI,NTHETA,NPHI,NF)
real fidd,fldo,incd,inco,decd,deco
dimension fidd(44,181),fldo(44,361),incd(44,181),inco(44,361),
>          decd(44,181),deco(44,361)
common /gmaf/ fidd,fldo,incd,inco,decd,deco
C
C ****
C THIS SUBROUTINE CALCULATES THE MAGNITUDE, INCLINATION, AND
C DECLINATION OF THE GEOMAGNETIC FIELD ON A GRID NTHETA BY
C NPHI
C ****

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C
C      THETA,PHI  **  ORIGIN OF THE GRID (DEG.)
C      ELV  **  ELEVATION OF GRID (KILO. ABOVE SEA LEVEL)
C      HTHETA,HPHI  **  GRID SPACING (DEG.)
C      NTHTETA,NPHI  **  DIMENSIONS OF THE GRID
C      NF  **  UNIT FILE WHICH WILL STORE THE FIELD
C
C      ****
C      SUBROUTINES USED
C      ** FIELDG ** (NASA)
C      ** FIELD ** (NASA)
C      ** WRITEB ** (SYSTEM)
C      ****
C
C      REAL F(361),INC(361),DEC(361)
C
C      write (6,*) ''
C      if (nf .eq. 10) then
C          write (6,*) 'the following is the geomagnetic field'
C          write (6,*) 'over the observation grid'
C      elseif (nf .eq. 11) then
C          write (6,*) 'the following is the geomagnetic field'
C          write (6,*) 'over the source grid'
C      endif
C      write (6,*) ''
C
C      LL=0
C      YYYYYY=THETA
C      XXXXXX=PHI
C
C      DO 120 I=1,NTHTETA
C          PHI=XXXXXX
C          DO 110 J=1,NPHI
C
C              CALL FIELDG (THETA,PHI,ELV,YEAR,50,LL,X,Y,Z,F (J))
C
C              H=SQRT(X**2+Y**2)
C              INC (J)=ATAN2 (Z,H)
C              DEC (J)=ATAN2 (Y,X)
C              PHI=PHI+HPHI
C
C 110      CONTINUE
C
C----- change 6 to nf in write statement
C----- if separate files for g.m.f.o.o.
C----- and g.m.f.o.s is wanted. don't forget
C----- to also use open statements.
C
C      WRITE (6,9981) (F (L),L=1,NPHI)
C      WRITE (6,9981) (INC (L),L=1,NPHI)
C      WRITE (6,9981) (DEC (L),L=1,NPHI)
C      write (67,9981) (f (l),l=1,nphi)
C      write (68,9981) ((inc (l)*57.295828),l=1,nphi)
C      write (69,9981) ((dec (l)*57.295828),l=1,nphi)
C
C 9981      format (4(1x,f19.9))
C
C      if (nf .eq. 11) then
C          do 710 l=1,nphi
C              fldd (l,1)=f (l)
C              incd (l,1)=inc (l)
C              decd (l,1)=dec (l)
C
C 710      continue
C      else if (nf .eq. 10) then
C          do 720 l=1,nphi
C              fido (l,1)=f (l)
C              inco (l,1)=inc (l)
C              deco (l,1)=dec (l)
C
C 720      continue
C      endif
C      THETA=THETA+HTHETA
C
C 120      CONTINUE
C
C      PHI=XXXXXX
C      THETA=YYYYYY
C      RETURN
C
C      END
C      SUBROUTINE FIELDG (DLAT,DLONG,ALT,TM,NMX,L,X,Y,Z,F)
C
C      ****
C      FOR DOCUMENTATION OF THIS SUBROUTINE AND SUBROUTINE FIELD SEE :
C      NATIONAL SPACE SCIENCE DATA CENTER'S PUBLICATION
C      **COMPUTATION OF THE MAIN GEOMAGNETIC FIELD
C      FROM SPHERICAL HARMONIC EXPANSIONS**
C      DATA USERS' NOTE, NSSDC 68-11, MAY 1968
C      GODDARD SPACE FLIGHT CENTER, GREENBELT, MD.
C      ****
C
C      DLAT ** LATITUDE IN DEGREES POSITIVE NORTH

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C      DLONG ** LONGITUDE IN DEGREES POSITIVE EAST
C      ALT ** ELEVATION IN KM (POSITIVE ABOVE, NEGATIVE BELOW
C          EARTH'S SURFACE)
C      TM ** EPOCH IN YEARS
C      NMX ** SET TO INTEGER GREATER THAN DEGREE OF EXPANSION
C          L ** SET TO 1 ON INITIAL DUMMY CALL, SET TO 0 ON SUBSEQUENT
C          CALLS
C
C      SUBROUTINE RETURNS GEOMAGNETIC FIELD DIRECTIONS (X,Y,Z), POSI-
C      TIVE NORTH, EAST AND DOWN, RESPECTIVELY, AND MAGNITUDE OF TOTAL
C      FIELD, F--ALL VALUES ARE IN GAMMAS
C
C      EQUIVALENCE (SHMIT(1,1),TG(1,1))
C      COMMON /NASA/ TG(55,55)
C      COMMON /FLDCOM/ CPH,SPH,R,CT,ST,BT,BP,BR,B
C      COMMON /MAX/  NMAX
C      DIMENSION G(55,55), GT(55,55), SHMIT(55,55), AID(55), GTT(55,55)
C      DATA A/0./
C
C      TLAST=0.0
C
C      IF (A.EQ.6378.16) IF(L) 210,100,110
C
C      A=6378.16
C      FLAT=1.-1./298.25
C      A2=A**2
C      A4=A**4
C      B2=(A*FLAT)**2
C      A2B2=A2*(1.-FLAT**2)
C      A4B4=A4*(1.-FLAT**4)
C      IF (L) 160,160,110
100   IF (TM-TLAST) 190,210,190
110   READ (3,260) J,K,TZERO, (AID(I), I=1,11)
      L=0
C      WRITE(6,270) J,K,TZERO, (AID(I), I=1,11)
      MAXN=0
      TEMP=0.
120   READ (3,280) N,M,GNM,HNM,GTNM,HTNM,GTINM,HTINM
      IF (N.LE.0) GO TO 130
      MAXN=(MAX0(N,MAXN))
      G(N,M)=GNM
      GT(N,M)=GTNM
      GTT(N,M)=GTINM
      TEMP=AMAX1(TEMP,ABS(GTNM))
      IF (M.EQ.1) GO TO 120
      G(M-1,N)=HNM
      GT(M-1,N)=HTNM
      GTT(M-1,N)=HTINM
      GO TO 120
130   continue
      rewind (3)
c 130  WRITE(6,290)
c      DO 150 N=2,MAXN
c      DO 150 M=1,N
c          MI=M-1
c          IF (M.EQ.1) GO TO 140
c          WRITE(6,300) N,M,G(N,M),G(MI,N),GT(N,M),GT(MI,N),GTT(N,M),GTT(
c          1 MI,N)
c          GO TO 150
c 140   WRITE(6,310) N,M,G(N,M),GT(N,M),GTT(N,M)
c 150  CONTINUE
      WRITE (6,320)
      IF (TEMP.EQ.0.) L=-1
160   IF (K.NE.0) GO TO 190
      SHMIT(1,1)=-1.
      DO 170 N=2,MAXN
          SHMIT(N,1)=SHMIT(N-1,1)*FLOAT(2*N-3)/FLOAT(N-1)
          SHMIT(1,N)=0.
          JJ=2
          DO 170 M=2,N
              SHMIT(N,M)=SHMIT(N,M-1)*SQRT(FLOAT((N-M+1)*JJ)/FLOAT(N+M-2))
              SHMIT(M-1,N)=SHMIT(N,M)
170   JJ=1
      DO 180 N=2,MAXN
      DO 180 M=1,N
          G(N,M)=G(N,M)*SHMIT(N,M)
          GT(N,M)=GT(N,M)*SHMIT(N,M)
          GTT(N,M)=GTT(N,M)*SHMIT(N,M)
          IF (M.EQ.1) GO TO 180
          G(M-1,N)=G(M-1,N)*SHMIT(M-1,N)
          GT(M-1,N)=GT(M-1,N)*SHMIT(M-1,N)
          GTT(M-1,N)=GTT(M-1,N)*SHMIT(M-1,N)
180   CONTINUE
190   T=TM-TZERO
      DO 200 N=1,MAXN
      DO 200 M=1,N
          TG(N,M)=G(N,M)+T*(GT(N,M)+GTT(N,M)*T)
          IF (M.EQ.1) GO TO 200
          TG(M-1,N)=G(M-1,N)+T*(GT(M-1,N)+GTT(M-1,N)*T)

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200 CONTINUE
      TLAST-TM
210 DLATR=DLAT/57.2957795
      SINLA=SIN(DLATR)
      RLONG=DLONG/57.2957795
      CPH=COS(RLONG)
      SPH=SIN(RLONG)
      IF (J.EQ.0) GO TO 220
      R=ALT+6371.0
      CT=SINLA
      GO TO 230
220 SINLA2=SINLA**2
      COSLA2=1.-SINLA2
      DEN2=A2-A2B2*SINLA2
      DEN=SQRT(DEN2)
      FAC=(((ALT*DEN)+A2)/((ALT*DEN)+B2))**2
      CT=SINLA/SQRT(FAC*COSLA2+SINLA2)
      R=SQRT(ALT**2+DEN)+(A4-A4B4*SINLA2)/DEN2
230 ST=SQRT(1.-CT**2)
      NMAX=MIN0(NMX,MAXN)
C      CALL FIELD
C      Y=BP
C      F=B
      IF (J) 240,250,240
240 X=-BT
      Z=-BR
      RETURN
C      TRANSFORMS FIELD TO GEODETIC DIRECTIONS
C      250 SIND=SINLA*ST-SQRT(COSLA2)*CT
      COSD=SQRT(1.0-SIND**2)
      X=-BT*COSD-BR*SIND
      Z=BT*SIND-BR*COSD
      RETURN
C      260 FORMAT (2I1,1X,F6.1,10A6,A3)
270 FORMAT (2I3,5X,6HEPOCH ,F7.1,5X,10A6,A3)
280 FORMAT (2I3,6F11.4)
290 FORMAT (6H0 N M,6X,1HG,10X,1HH,9X,2HGT,9X,2HHT,8X,3HGTT,8X,3HHTT//1)
300 FORMAT (2I3,6F11.4)
310 FORMAT (2I3,F11.4,11X,F11.4,11X,F11.4)
320 FORMAT (///)
C      END
C      SUBROUTINE FIELD
C      COMMON /NASA/ G(55,55)
      COMMON /FLDCOM/ CPH,SPH,R,CT,ST,BT,BP,BR,B
      COMMON /MAX/ NMAX
      DIMENSION P(55,55), DP(55,55), CONST(55,55), SP(55), CP(55),
> FN(55), FM(55)
      DATA P(1,1)/0./
C      IF (P(1,1).EQ.1.0) GO TO 120
      P(1,1)=1.
      DP(1,1)=0.
      SP(1)=0.
      CP(1)=1.
      DO 110 N=2,18
      FN(N)=N
      DO 110 M=1,N
      FM(M)=M-1
110 CONST(N,M)=FLOAT((N-2)**2-(M-1)**2)/FLOAT((2*N-3)*(2*N-5))
120 SP(2)=SPH
      CP(2)=CPH
      DO 130 M=3,NMAX
      SP(M)=SP(2)*CP(M-1)+CP(2)*SP(M-1)
130 CP(M)=CP(2)*CP(M-1)-SP(2)*SP(M-1)
      AOR=6371.0/R
      AR=AOR**2
      BT=0.
      BP=0.
      BR=0.
      DO 190 N=2,NMAX
      AR=AOR*AR
      DO 190 M=1,N
      IF (N-M) 150,140,150
140  P(N,N)=ST*P(N-1,N-1)
      DP(N,N)=ST*DP(N-1,N-1)+CT*P(N-1,N-1)
      GO TO 160
150  P(N,M)=CT*P(N-1,M)-CONST(N,M)*P(N-2,M)
      DP(N,M)=CT*DP(N-1,M)-ST*P(N-1,M)-CONST(N,M)*DP(N-2,M)
160  PAR=P(N,M)*AR
      IF (M.EQ.1) GO TO 170

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        TEMP=G (N,M) *CP (M) +G (M-1,N) *SP (M)
        BP=BP- (G (N,M) *SP (M) -G (M-1,N) *CP (M) ) *FM (M) *PAR
        GO TO 180
170    TEMP=G (N,M) *CP (M)
        BP=BP- (G (N,M) *SP (M) ) *FM (M) *PAR
180    BT=BT+TEMP*DP (N,M) *AR
190    BR=BR-TEMP*FN (N) *PAR
        BP=BP/ST
        B=SORT (BT*BT+BP*BP+BR*BR)
        RETURN
C
        END
        SUBROUTINE SPPCO (AP, N, RCOND, Z, INFO)
        INTEGER N, INFO
        REAL AP (1), Z (1)
        REAL RCOND
C
C       SPPCO FACTORS A REAL SYMMETRIC POSITIVE DEFINITE MATRIX
C       STORED IN PACKED FORM
C       AND ESTIMATES THE CONDITION OF THE MATRIX.
C
C       IF RCOND IS NOT NEEDED, SPPFA IS SLIGHTLY FASTER.
C       TO SOLVE A*X = B, FOLLOW SPPCO BY SPPSL.
C       TO COMPUTE INVERSE(A)*C, FOLLOW SPPCO BY SPPSL.
C       TO COMPUTE DETERMINANT(A), FOLLOW SPPCO BY SPPDI.
C       TO COMPUTE INVERSE(A), FOLLOW SPPCO BY SPPDI.
C
C       ON ENTRY
C
C       AP      REAL (N*(N+1)/2)
C               THE PACKED FORM OF A SYMMETRIC MATRIX A. THE
C               COLUMNS OF THE UPPER TRIANGLE ARE STORED SEQUENTIALLY
C               IN A ONE-DIMENSIONAL ARRAY OF LENGTH N*(N+1)/2 .
C               SEE COMMENTS BELOW FOR DETAILS.
C
C       N      INTEGER
C               THE ORDER OF THE MATRIX A .
C
C       ON RETURN
C
C       AP      AN UPPER TRIANGULAR MATRIX R, STORED IN PACKED
C               FORM, SO THAT A = TRANS(R)*R .
C               IF INFO .NE. 0, THE FACTORIZATION IS NOT COMPLETE.
C
C       RCOND   REAL
C               AN ESTIMATE OF THE RECIPROCAL CONDITION OF A .
C               FOR THE SYSTEM A*X = B, RELATIVE PERTURBATIONS
C               IN A AND B OF SIZE EPSILON MAY CAUSE
C               RELATIVE PERTURBATIONS IN X OF SIZE EPSILON/RCOND .
C               IF RCOND IS SO SMALL THAT THE LOGICAL EXPRESSION
C               1.0 + RCOND .EQ. 1.0
C               IS TRUE, THEN A MAY BE SINGULAR TO WORKING
C               PRECISION. IN PARTICULAR, RCOND IS ZERO IF
C               EXACT SINGULARITY IS DETECTED OR THE ESTIMATE
C               UNDERFLOWS. IF INFO .NE. 0, RCOND IS UNCHANGED.
C
C       Z      REAL (N)
C               A WORK VECTOR WHOSE CONTENTS ARE USUALLY UNIMPORTANT.
C               IF A IS SINGULAR TO WORKING PRECISION, THEN Z IS
C               AN APPROXIMATE NULL VECTOR IN THE SENSE THAT
C               NORM(A*Z) = RCOND*NORM(A)*NORM(Z) .
C               IF INFO .NE. 0, Z IS UNCHANGED.
C
C       INFO    INTEGER
C               = 0 FOR NORMAL RETURN.
C               = K SIGNALS AN ERROR CONDITION. THE LEADING MINOR
C               OF ORDER K IS NOT POSITIVE DEFINITE.
C
C       PACKED STORAGE
C
C               THE FOLLOWING PROGRAM SEGMENT WILL PACK THE UPPER
C               TRIANGLE OF A SYMMETRIC MATRIX.
C
C               K = 0
C               DO 20 J = 1, N
C                   DO 10 I = 1, J
C                       K = K + 1
C                       AP(K) = A(I,J)
C 10      CONTINUE
C 20      CONTINUE
C
C               LINPACK. THIS VERSION DATED 08/14/78 .
C               CLEVE MOLER, UNIVERSITY OF NEW MEXICO, ARGONNE NATIONAL LAB.
C
C               SUBROUTINES AND FUNCTIONS
C
C               LINPACK SPPFA
C               BLAS SAXPY, SDOT, SSCAL, SASUM
C               FORTRAN ABS, AMAX1, REAL, SIGN
C
C               INTERNAL VARIABLES

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C
REAL SDOT,EK,T,WK,WKM
REAL ANORM,S,SASUM,SM,YNORM
INTEGER I,IJ,J,JM1,J1,K,KB,KJ,KK,KP1
C
C FIND NORM OF A
C
J1 = 1
DO 30 J = 1, N
  Z(J) = SASUM(J,AP(J1),1)
  IJ = J1
  J1 = J1 + J
  JM1 = J - 1
  IF (JM1 .LT. 1) GO TO 20
  DO 10 I = 1, JM1
    Z(I) = Z(I) + ABS(AP(IJ))
    IJ = IJ + 1
10  CONTINUE
20  CONTINUE
30 CONTINUE
  ANORM = 0.0E0
  DO 40 J = 1, N
    ANORM = AMAX1(ANORM,Z(J))
40  CONTINUE
C
C FACTOR
C
CALL SPPFA(AP,N,INFO)
IF (INFO .NE. 0) GO TO 180
C
RCOND = 1/(NORM(A)*(ESTIMATE OF NORM(INVERSE(A)))). .
ESTIMATE = NORM(Z)/NORM(Y) WHERE A*Z = Y AND A*Y = E .
THE COMPONENTS OF E ARE CHOSEN TO CAUSE MAXIMUM LOCAL
GROWTH IN THE ELEMENTS OF W WHERE TRANS(R)*W = E .
THE VECTORS ARE FREQUENTLY RESCALED TO AVOID OVERFLOW.
C
C SOLVE TRANS(R)*W = E
C
EK = 1.0E0
DO 50 J = 1, N
  Z(J) = 0.0E0
50  CONTINUE
  KK = 0
  DO 110 K = 1, N
    KK = KK + K
    IF (Z(K) .NE. 0.0E0) EK = SIGN(EK,-Z(K))
    IF (ABS(EK-Z(K)) .LE. AP(KK)) GO TO 60
    S = AP(KK)/ABS(EK-Z(K))
    CALL SSCAL(N,S,Z,1)
    EK = S*EK
60  CONTINUE
  WK = EK - Z(K)
  WKM = -EK - Z(K)
  S = ABS(WK)
  SM = ABS(WKM)
  WK = WK/AP(KK)
  WKM = WKM/AP(KK)
  KP1 = K + 1
  KJ = KK + K
  IF (KP1 .GT. N) GO TO 100
  DO 70 J = KP1, N
    SM = SM + ABS(Z(J)+WKM*AP(KJ))
    Z(J) = Z(J) + WK*AP(KJ)
    S = S + ABS(Z(J))
    KJ = KJ + J
70  CONTINUE
  IF (S .GE. SM) GO TO 90
    T = WKM - WK
    WK = WKM
    KJ = KK + K
    DO 80 J = KP1, N
      Z(J) = Z(J) + T*AP(KJ)
      KJ = KJ + J
80  CONTINUE
90  CONTINUE
100  CONTINUE
  Z(K) = WK
110  CONTINUE
  S = 1.0E0/SASUM(N,Z,1)
  CALL SSCAL(N,S,Z,1)
C
C SOLVE R*Y = W
C
DO 130 KB = 1, N
  K = N + 1 - KB
  IF (ABS(Z(K)) .LE. AP(KK)) GO TO 120
  S = AP(KK)/ABS(Z(K))
  CALL SSCAL(N,S,Z,1)
120  CONTINUE

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      Z(K) = Z(K)/AP(KK)
      KK = KK - K
      T = -2(K)
      CALL SAXPY(K-1,T,AP(KK+1),1,Z(1),1)
130  CONTINUE
      S = 1.0E0/SASUM(N,Z,1)
      CALL SSCAL(N,S,Z,1)
C      YNORM = 1.0E0
C      SOLVE TRANS(R)*V = Y
C
      DO 150 K = 1, N
      Z(K) = Z(K) - SDOT(K-1,AP(KK+1),1,Z(1),1)
      KK = KK + K
      IF (ABS(Z(K)) .LE. AP(KK)) GO TO 140
      S = AP(KK)/ABS(Z(K))
      CALL SSCAL(N,S,Z,1)
      YNORM = S*YNORM
140  CONTINUE
      Z(K) = Z(K)/AP(KK)
150  CONTINUE
      S = 1.0E0/SASUM(N,Z,1)
      CALL SSCAL(N,S,Z,1)
      YNORM = S*YNORM
C      SOLVE R*Z = V
C
      DO 170 KB = 1, N
      K = N + 1 - KB
      IF (ABS(Z(K)) .LE. AP(KK)) GO TO 160
      S = AP(KK)/ABS(Z(K))
      CALL SSCAL(N,S,Z,1)
      YNORM = S*YNORM
160  CONTINUE
      Z(K) = Z(K)/AP(KK)
      KK = KK - K
      T = -2(K)
      CALL SAXPY(K-1,T,AP(KK+1),1,Z(1),1)
170  CONTINUE
C      MAKE ZNORM = 1.0
      S = 1.0E0/SASUM(N,Z,1)
      CALL SSCAL(N,S,Z,1)
      YNORM = S*YNORM
C
      IF (ANORM .NE. 0.0E0) RCOND = YNORM/ANORM
      IF (ANORM .EQ. 0.0E0) RCOND = 0.0E0
180 CONTINUE
      RETURN
      END
      SUBROUTINE SPPFA(AP,N,INFO)
      INTEGER N,INFO
      REAL AP(1)
C
C      SPPFA FACTORS A REAL SYMMETRIC POSITIVE DEFINITE MATRIX
C      STORED IN PACKED FORM.
C
C      SPPFA IS USUALLY CALLED BY SPPCO, BUT IT CAN BE CALLED
C      DIRECTLY WITH A SAVING IN TIME IF RCOND IS NOT NEEDED.
C      (TIME FOR SPPCO) = (1 + 18/N)*(TIME FOR SPPFA) .
C
C      ON ENTRY
C
C      AP      REAL (N*(N+1)/2)
C              THE PACKED FORM OF A SYMMETRIC MATRIX A . THE
C              COLUMNS OF THE UPPER TRIANGLE ARE STORED SEQUENTIALLY
C              IN A ONE-DIMENSIONAL ARRAY OF LENGTH N*(N+1)/2 .
C              SEE COMMENTS BELOW FOR DETAILS.
C
C      N      INTEGER
C              THE ORDER OF THE MATRIX A .
C
C      ON RETURN
C
C      AP      AN UPPER TRIANGULAR MATRIX R , STORED IN PACKED
C              FORM, SO THAT A = TRANS(R)*R .
C
C      INFO     INTEGER
C              = 0 FOR NORMAL RETURN.
C              = K IF THE LEADING MINOR OF ORDER K IS NOT
C              POSITIVE DEFINITE.
C
C      PACKED STORAGE
C
C              THE FOLLOWING PROGRAM SEGMENT WILL PACK THE UPPER
C              TRIANGLE OF A SYMMETRIC MATRIX.
C
C      K = 0
      DO 20 J = 1, N

```

```

C          DO 10 I = 1, J
C          K = K + 1
C          AP(K) = A(I,J)
C 10      CONTINUE
C 20      CONTINUE
C
C LINPACK. THIS VERSION DATED 08/14/78 .
C CLEVE MOLER, UNIVERSITY OF NEW MEXICO, ARGONNE NATIONAL LAB.
C
C SUBROUTINES AND FUNCTIONS
C
C BLAS SDOT
C FORTRAN SQRT
C
C INTERNAL VARIABLES
C
C      REAL SDOT,T
C      REAL S
C      INTEGER J,JJ,JM1,K,KJ,KK
C      BEGIN BLOCK WITH ...EXITS TO 40
C
C      JJ = 0
C      DO 30 J = 1, N
C          INFO = J
C          S = 0.0E0
C          JM1 = J - 1
C          KJ = JJ
C          KK = 0
C          IF (JM1 .LT. 1) GO TO 20
C          DO 10 K = 1, JM1
C              KJ = KJ + 1
C              T = AP(KJ) - SDOT(K-1,AP(KK+1),1,AP(JJ+1),1)
C              KK = KK + K
C              T = T/AP(KK)
C              AP(KJ) = T
C              S = S + T*T
C 10      CONTINUE
C 20      CONTINUE
C          JJ = JJ + J
C          S = AP(JJ) - S
C
C      ..... EXIT
C      IF (S .LE. 0.0E0) GO TO 40
C      AP(JJ) = SQRT(S)
C 30      CONTINUE
C          INFO = 0
C 40      CONTINUE
C          RETURN
C          END
C          SUBROUTINE SAXPY (N,SA,SX,INCX,SY,INCY)
C
C-----
```

C COMPUTER - CDC/SINGLE

C LATEST REVISION - JANUARY 1, 1978

C PURPOSE - COMPUTE A CONSTANT TIMES A VECTOR PLUS
A VECTOR, ALL SINGLE PRECISION

C USAGE - CALL SAXPY (N,SA,SX,INCX,SY,INCY)

C ARGUMENTS N - LENGTH OF VECTORS X AND Y. (INPUT)

C SA - REAL SCALAR. (INPUT)

C SX - REAL VECTOR OF LENGTH MAX(N*IABS(INCX),1).
(INPUT)

C INCX - DISPLACEMENT BETWEEN ELEMENTS OF SX. (INPUT)
X(I) IS DEFINED TO BE..
SX(I+(I-1)*INCX) IF INCX.GE.0 OR
SX(I+(I-N)*INCX) IF INCX.LT.0.

C SY - REAL VECTOR OF LENGTH MAX(N*IABS(INCY),1).
(INPUT/OUTPUT)
SAXPY REPLACES Y(I) WITH SA*X(I)+Y(I)
FOR I=1,...,N.
X(I) AND Y(I) REFER TO SPECIFIC ELEMENTS
OF SX AND SY, RESPECTIVELY. SEE INCX AND
INCY ARGUMENT DESCRIPTIONS.

C INCY - DISPLACEMENT BETWEEN ELEMENTS OF SY. (INPUT)
Y(I) IS DEFINED TO BE..
SY(I+(I-1)*INCY) IF INCY.GE.0 OR
SY(I+(I-N)*INCY) IF INCY.LT.0.

C PRECISION/HARDWARE - SINGLE/ALL

C REQD. IMSL ROUTINES - NONE REQUIRED

C NOTATION - INFORMATION ON SPECIAL NOTATION AND
CONVENTIONS IS AVAILABLE IN THE MANUAL
INTRODUCTION OR THROUGH IMSL ROUTINE UHELP

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SPECIFICATIONS FOR ARGUMENTS
 INTEGER N, INCX, INCY
 REAL SX(1), SY(1), SA
 SPECIFICATIONS FOR LOCAL VARIABLES
 INTEGER I, IX, IY, M, MP1, NS
 FIRST EXECUTABLE STATEMENT
 IF (N.LE.0.OR.SA.EQ.0.EQ.0) RETURN
 IF (INCX.EQ.INCY) IF (INCX-1) 5,15,35
 5 CONTINUE
 CODE FOR NONEQUAL OR NONPOSITIVE
 INCREMENTS.
 IX = 1
 IY = 1
 IF (INCX.LT.0) IX = (-N+1)*INCX+1
 IF (INCY.LT.0) IY = (-N+1)*INCY+1
 DO 10 I=1,N
 SY(IY) = SY(IY)+SA*SX(IX)
 IX = IX+INCX
 IY = IY+INCY
 10 CONTINUE
 RETURN
 CODE FOR BOTH INCREMENTS EQUAL TO 1
 CLEAN-UP LOOP SO REMAINING VECTOR
 LENGTH IS A MULTIPLE OF 4.
 15 M = N-(N/4)*4
 IF (M.EQ.0) GO TO 25
 DO 20 I=1,M
 SY(I) = SY(I)+SA*SX(I)
 20 CONTINUE
 IF (N.LT.4) RETURN
 25 MP1 = M+1
 DO 30 I=MP1,N,4
 SY(I) = SY(I)+SA*SX(I)
 SY(I+1) = SY(I+1)+SA*SX(I+1)
 SY(I+2) = SY(I+2)+SA*SX(I+2)
 SY(I+3) = SY(I+3)+SA*SX(I+3)
 30 CONTINUE
 RETURN
 CODE FOR EQUAL, POSITIVE, NONUNIT
 INCREMENTS.
 35 CONTINUE
 NS = N*INCX
 DO 40 I=1,NS,INCX
 SY(I) = SA*SX(I)+SY(I)
 40 CONTINUE
 RETURN
 END
 REAL FUNCTION SDOT (N, SX, INCX, SY, INCY)

COMPUTER - CDC/SINGLE
 LATEST REVISION - JANUARY 1, 1978
 PURPOSE - COMPUTE SINGLE PRECISION DOT PRODUCT
 USAGE - FUNCTION SDOT (N, SX, INCX, SY, INCY)
 ARGUMENTS SDOT - SUM FROM I=1 TO N OF X(I)*Y(I). (OUTPUT)
 X(I) AND Y(I) REFER TO SPECIFIC ELEMENTS
 OF SX AND SY, RESPECTIVELY. SEE INCX AND
 INCY ARGUMENT DESCRIPTIONS.
 N - LENGTH OF VECTORS X AND Y. (INPUT)
 SX - REAL VECTOR OF LENGTH MAX(N*IABS(INCX),1).
 INCX - DISPLACEMENT BETWEEN ELEMENTS OF SX. (INPUT)
 X(I) IS DEFINED TO BE..
 SX(1+(I-1)*INCX) IF INCX.GE.0 OR
 SX(1+(I-N)*INCX) IF INCX.LT.0.
 SY - REAL VECTOR OF LENGTH MAX(N*IABS(INCY),1).
 INCY - DISPLACEMENT BETWEEN ELEMENTS OF SY. (INPUT)
 Y(I) IS DEFINED TO BE..
 SY(1+(I-1)*INCY) IF INCY.GE.0 OR
 SY(1+(I-N)*INCY) IF INCY.LT.0.
 PRECISION/HARDWARE - SINGLE/ALL
 REQD. IMSL ROUTINES - NONE REQUIRED

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C                  EXPRESSED OR IMPLIED, IS APPLICABLE.
C
C-----  

C
C  SPECIFICATIONS FOR ARGUMENTS
C
C      INTEGER      N, INCX, INCY
C      REAL         SX(1), SY(1)
C
C  SPECIFICATIONS FOR LOCAL VARIABLES
C
C      INTEGER      I, M, MP1, NS, IX, IY
C
C  FIRST EXECUTABLE STATEMENT
C
C      SDOT = 0.0E0
C      IF (N.LE.0) RETURN
C      IF (INCX.EQ.INCY) IF (INCX-1) 5,15,35
C  5 CONTINUE
C
C  CODE FOR UNEQUAL INCREMENTS OR
C  NONPOSITIVE INCREMENTS.
C
C      IX = 1
C      IY = 1
C      IF (INCX.LT.0) IX = (-N+1)*INCX+1
C      IF (INCY.LT.0) IY = (-N+1)*INCY+1
C      DO 10 I=1,N
C          SDOT = SDOT+SX(IX)*SY(IY)
C          IX = IX+INCX
C          IY = IY+INCY
C  10 CONTINUE
C      RETURN
C
C  CODE FOR BOTH INCREMENTS EQUAL TO 1
C  CLEAN-UP LOOP SO REMAINING VECTOR
C  LENGTH IS A MULTIPLE OF 5.
C
C  15 M = N-(N/5)*5
C      IF (M.EQ.0) GO TO 25
C      DO 20 I=1,M
C          SDOT = SDOT+SX(I)*SY(I)
C  20 CONTINUE
C      IF (N.LT.5) RETURN
C  25 MP1 = M+1
C      DO 30 I=MP1,N,5
C          SDOT = SDOT+SX(I)*SY(I)+SX(I+1)*SY(I+1)+SX(I+2)*SY(I+2)+SX(I
C          +3)*SY(I+3)+SX(I+4)*SY(I+4)
C  30 CONTINUE
C      RETURN
C
C  CODE FOR POSITIVE EQUAL INCREMENTS
C  .NE.1.
C
C  35 CONTINUE
C      NS = N*INCX
C      DO 40 I=1,NS,INCX
C          SDOT = SDOT+SX(I)*SY(I)
C  40 CONTINUE
C      RETURN
C      END
C      SUBROUTINE SSCAL (N, SA, SX, INCX)
C
C-----  

C
C  COMPUTER      - CDC/SINGLE
C
C  LATEST REVISION - JANUARY 1, 1978
C
C  PURPOSE        - COMPUTE A SINGLE PRECISION CONSTANT
C                  TIMES A SINGLE PRECISION VECTOR
C
C  USAGE          - CALL SSCAL (N, SA, SX, INCX)
C
C  ARGUMENTS      N      - LENGTH OF VECTOR X. (INPUT)
C                  SA     - REAL SCALAR. (INPUT)
C                  SX     - REAL VECTOR OF LENGTH N*INCX. (INPUT/OUTPUT)
C                          SSCAL REPLACES X(I) WITH SA*X(I) FOR
C                          I=1,...,N.
C                          X(I) REFERS TO A SPECIFIC ELEMENT OF SX.
C                          SEE INCX ARGUMENT DESCRIPTION.
C
C                  INCX   - DISPLACEMENT BETWEEN ELEMENTS OF SX. (INPUT)
C                          X(I) IS DEFINED TO BE SX(1+(I-1)*INCX).
C                          INCX MUST BE GREATER THAN ZERO.
C
C  PRECISION/HARDWARE - SINGLE/ALL
C
C  REQD. IMSL ROUTINES - NONE REQUIRED
C
C  NOTATION       - INFORMATION ON SPECIAL NOTATION AND
C                  CONVENTIONS IS AVAILABLE IN THE MANUAL
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C
C-----C
C          SPECIFICATIONS FOR ARGUMENTS
C
C      INTEGER      INCX, N
C      REAL         SA, SX(1)
C
C      INTEGER      I, M, MP1, NS
C
C      IF (N.LE.0) RETURN
C      IF (INCX.EQ.1) GO TO 10
C
C      NS = N*INCX
C      DO 5 I=1,NS,INCX
C          SX(I) = SA*SX(I)
C
C 5 CONTINUE
C      RETURN
C
C          CODE FOR INCREMENTS EQUAL TO 1.
C          CLEAN-UP LOOP SO REMAINING VECTOR
C          LENGTH IS A MULTIPLE OF 5.
C
C 10 M = N-(N/5)*5
C      IF (M.EQ.0) GO TO 20
C      DO 15 I=1,M
C          SX(I) = SA*SX(I)
C
C 15 CONTINUE
C      IF (N.LT.5) RETURN
C
C 20 MP1 = M+1
C      DO 25 I=MP1,N,5
C          SX(I) = SA*SX(I)
C          SX(I+1) = SA*SX(I+1)
C          SX(I+2) = SA*SX(I+2)
C          SX(I+3) = SA*SX(I+3)
C          SX(I+4) = SA*SX(I+4)
C
C 25 CONTINUE
C      RETURN
C
C      END
C
C      REAL FUNCTION SASUM (N, SX, INCX)
C
C-----C
C
C  COMPUTER      - CDC/SINGLE
C
C  LATEST REVISION - JANUARY 1, 1978
C
C  PURPOSE        - COMPUTE SINGLE PRECISION SUM OF ABSOLUTE
C                  VALUES
C
C  USAGE          - FUNCTION SASUM (N, SX, INCX)
C
C  ARGUMENTS      SASUM  - SUM FROM I=1 TO N OF ABS(X(I)). (OUTPUT)
C
C                  X(I) REFERS TO A SPECIFIC ELEMENT OF SX.
C                  SEE INCX ARGUMENT DESCRIPTION.
C
C                  N      - LENGTH OF VECTOR X. (INPUT)
C                  SX     - REAL VECTOR OF LENGTH N*INCX. (INPUT)
C                  INCX  - DISPLACEMENT BETWEEN ELEMENTS OF SX. (INPUT)
C
C                  X(I) IS DEFINED TO BE SX(1+(I-1)*INCX).
C                  INCX MUST BE GREATER THAN ZERO.
C
C  PRECISION/HARDWARE - SINGLE/ALL
C
C  REQD. IMSL ROUTINES - NONE REQUIRED
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C
C-----C
C          SPECIFICATIONS FOR ARGUMENTS
C
C      INTEGER      N, INCX
C      REAL         SX(1)
C
C      INTEGER      I, M, MP1, NS
C
C      FIRST EXECUTABLE STATEMENT
C
C      SASUM = 0.0E0
C      IF (N.LE.0) RETURN
C      IF (INCX.EQ.1) GO TO 10

```

```

C           CODE FOR INCREMENTS NOT EQUAL TO 1.
C
C           NS = N*INCX
C           DO 5 I=1,NS,INCX
C                 SASUM = SASUM+ABS(SX(I))
C
C           5 CONTINUE
C           RETURN
C           CODE FOR INCREMENTS EQUAL TO 1.
C           CLEAN-UP LOOP SO REMAINING VECTOR
C           LENGTH IS A MULTIPLE OF 6.
C
C           10 M = N-(N/6)*6
C               IF (M.EQ.0) GO TO 20
C               DO 15 I=1,M
C                     SASUM = SASUM+ABS(SX(I))
C
C           15 CONTINUE
C           IF (N.LT.6) RETURN
C
C           20 MP1 = M+1
C               DO 25 I=MP1,N,6
C                     SASUM = SASUM+ABS(SX(I))+ABS(SX(I+1))+ABS(SX(I+2))+ABS(SX(I
C                     1 +3))+ABS(SX(I+4))+ABS(SX(I+5))
C
C           25 CONTINUE
C           RETURN
C           END
C           SUBROUTINE SPPSL(AP,N,B)
C           INTEGER N
C           REAL AP(1),B(1)
C
C           SPPSL SOLVES THE REAL SYMMETRIC POSITIVE DEFINITE SYSTEM
C           A * X = B
C           USING THE FACTORS COMPUTED BY SPPCO OR SPPFA.
C
C           ON ENTRY
C
C           AP      REAL (N*(N+1)/2)
C           THE OUTPUT FROM SPPCO OR SPPFA.
C
C           N      INTEGER
C           THE ORDER OF THE MATRIX A .
C
C           B      REAL (N)
C           THE RIGHT HAND SIDE VECTOR.
C
C           ON RETURN
C
C           B      THE SOLUTION VECTOR X .
C
C           ERROR CONDITION
C
C           A DIVISION BY ZERO WILL OCCUR IF THE INPUT FACTOR CONTAINS
C           A ZERO ON THE DIAGONAL. TECHNICALLY THIS INDICATES
C           SINGULARITY BUT IT IS USUALLY CAUSED BY IMPROPER SUBROUTINE
C           ARGUMENTS. IT WILL NOT OCCUR IF THE SUBROUTINES ARE CALLED
C           CORRECTLY AND INFO .EQ. 0 .
C
C           TO COMPUTE INVERSE(A) * C WHERE C IS A MATRIX
C           WITH P COLUMNS
C               CALL SPPCO(AP,N,RCOND,Z,INFO)
C               IF (RCOND IS TOO SMALL .OR. INFO .NE. 0) GO TO ...
C               DO 10 J = 1, P
C                     CALL SPPSL(AP,N,C(1,J))
C
C           10 CONTINUE
C
C           LINPACK. THIS VERSION DATED 08/14/78 .
C           CLEVE MOLER, UNIVERSITY OF NEW MEXICO, ARGONNE NATIONAL LAB.
C
C           SUBROUTINES AND FUNCTIONS
C
C           BLAS SAXPY,SDOT
C
C           INTERNAL VARIABLES
C
C           REAL SDOT,T
C           INTEGER K,KB,KK
C
C           KK = 0
C           DO 10 K = 1, N
C                 T = SDOT(K-1,AP(KK+1),1,B(1),1)
C                 KK = KK + K
C                 B(K) = (B(K) - T)/AP(KK)
C
C           10 CONTINUE
C           DO 20 KB = 1, N
C                 K = N + 1 - KB
C                 B(K) = B(K)/AP(KK)
C                 KK = KK - K
C                 T = -B(K)
C                 CALL SAXPY(K-1,T,AP(KK+1),1,B(1),1)
C
C           20 CONTINUE
C           RETURN
C           END

```


0.00000000000000D+00 0.6259999871254D+00
0.1000000000000D+01 0.6259951659277D+00
0.2000000000000D+01 0.6259807025574D+00
0.3000000000000D+01 0.6259565976827D+00
0.4000000000000D+01 0.6259228524177D+00
0.5000000000000D+01 0.6258794683214D+00
0.6000000000000D+01 0.6258264473985D+00
0.7000000000000D+01 0.6257637920986D+00
0.8000000000000D+01 0.6256915053163D+00
0.9000000000000D+01 0.6256095903911D+00
0.1000000000000D+02 0.6255180511067D+00
0.1100000000000D+02 0.6254168916912D+00
0.1200000000000D+02 0.6253061168165D+00
0.1300000000000D+02 0.6251857315978D+00
0.1400000000000D+02 0.6250557415938D+00
0.1500000000000D+02 0.6249161528054D+00
0.1600000000000D+02 0.6247669716761D+00
0.1700000000000D+02 0.6246082050909D+00
0.1800000000000D+02 0.6244398603760D+00
0.1900000000000D+02 0.6242619452984D+00
0.2000000000000D+02 0.6240744680650D+00
0.2100000000000D+02 0.6238774373220D+00
0.2200000000000D+02 0.6236708621544D+00
0.2300000000000D+02 0.6234547520854D+00
0.2400000000000D+02 0.6232291170752D+00
0.2500000000000D+02 0.6229939675208D+00
0.2600000000000D+02 0.6227493142548D+00
0.2700000000000D+02 0.6224951685447D+00
0.2800000000000D+02 0.6222315420922D+00
0.2900000000000D+02 0.6219584470318D+00
0.3000000000000D+02 0.6216758959306D+00
0.3100000000000D+02 0.6213839017867D+00
0.3200000000000D+02 0.6210824780285D+00
0.3300000000000D+02 0.6207716385137D+00
0.3400000000000D+02 0.6204513975281D+00
0.3500000000000D+02 0.6201217697846D+00
0.3600000000000D+02 0.6197827704219D+00
0.3700000000000D+02 0.6194344150038D+00
0.3800000000000D+02 0.6190767195172D+00
0.3900000000000D+02 0.6187097003719D+00
0.4000000000000D+02 0.6183333743984D+00
0.4100000000000D+02 0.6179477588472D+00
0.4200000000000D+02 0.6175528713873D+00
0.4300000000000D+02 0.6171487301050D+00
0.4400000000000D+02 0.6167353535020D+00
0.4500000000000D+02 0.6163127604947D+00
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 0.44200000000000D+03 0.1390356477712D+00
 0.44300000000000D+03 0.1380912118362D+00
 0.44400000000000D+03 0.1371510786406D+00
 0.44500000000000D+03 0.1362152477545D+00
 0.44600000000000D+03 0.1352837185528D+00
 0.44700000000000D+03 0.1343564902166D+00
 0.44800000000000D+03 0.1334335617344D+00
 0.44900000000000D+03 0.1325149319039D+00

0.45000000000000D+03 0.1316005993328D+00
 0.45100000000000D+03 0.1306905624408D+00
 0.45200000000000D+03 0.1297848194604D+00
 0.45300000000000D+03 0.1288833684389D+00
 0.45400000000000D+03 0.1279862072394D+00
 0.45500000000000D+03 0.1270933335422D+00
 0.45600000000000D+03 0.1262047448465D+00
 0.45700000000000D+03 0.1253204384716D+00
 0.45800000000000D+03 0.1244404115582D+00
 0.45900000000000D+03 0.1235646610704D+00
 0.46000000000000D+03 0.1226931837962D+00
 0.46100000000000D+03 0.1218259763500D+00
 0.46200000000000D+03 0.1209630351731D+00
 0.46300000000000D+03 0.1201043565357D+00
 0.46400000000000D+03 0.1192499365382D+00
 0.46500000000000D+03 0.1183997711125D+00
 0.46600000000000D+03 0.1175538560237D+00
 0.46700000000000D+03 0.1167121868713D+00
 0.46800000000000D+03 0.1158747590909D+00
 0.46900000000000D+03 0.1150415679556D+00
 0.47000000000000D+03 0.1142126085770D+00
 0.47100000000000D+03 0.1133878759075D+00
 0.47200000000000D+03 0.1125673647410D+00
 0.47300000000000D+03 0.1117510697147D+00
 0.47400000000000D+03 0.1109389853108D+00
 0.47500000000000D+03 0.1101311058574D+00
 0.47600000000000D+03 0.1093274255303D+00
 0.47700000000000D+03 0.1085279383544D+00
 0.47800000000000D+03 0.1077326382055D+00
 0.47900000000000D+03 0.1069415188111D+00
 0.48000000000000D+03 0.1061545737523D+00
 0.48100000000000D+03 0.1053717964654D+00
 0.48200000000000D+03 0.1045931802429D+00
 0.48300000000000D+03 0.1038187182355D+00
 0.48400000000000D+03 0.1030484034532D+00
 0.48500000000000D+03 0.1022822287667D+00
 0.48600000000000D+03 0.1015201869094D+00
 0.48700000000000D+03 0.1007622704782D+00
 0.48800000000000D+03 0.1000084719356D+00
 0.48900000000000D+03 0.9925878361054D-01
 0.49000000000000D+03 0.9851319770041D-01
 0.49100000000000D+03 0.9777170627220D-01
 0.49200000000000D+03 0.9703430126409D-01
 0.49300000000000D+03 0.9630097448686D-01
 0.49400000000000D+03 0.9557171762539D-01
 0.49500000000000D+03 0.9484652224011D-01
 0.49600000000000D+03 0.9412537976844D-01
 0.49700000000000D+03 0.9340828152630D-01
 0.49800000000000D+03 0.9269521870950D-01
 0.49900000000000D+03 0.9198618239525D-01

APPENDIX D: STATISTICS AND DATA CONVERSIONS

D.1 CHECK

Check is used for quickly defining the basic statistics (minimum, maximum, average, difference between adjacent points and variance) of an individual pass. If any one of the parameters is outside of the acceptable limits, then the pass number and all parameters are written to the screen. Rerunning this program several times while varying the cutoff limits helps to assess the general quality of the input data.

D.2 STATMAT

This program finds the standard statistics of any of the grids of Chapter III. If more than one grid is input, then the correlation coefficients between all possible map-to-map comparisons are also found. **Statmat** should be used to determine the similarities and differences between dawn and dusk maps and between continued maps.

D.3 PART2

This program was written by Dr. Gary P. Murdock and is used to convert the three Investigator-B tapes supplied by NASA on an IBM platform to a Digital Equipment Corporation (DEC) platform. The program converts IBM text and fixed point and floating point numbers to their respective representation on the DEC machine. Similar code can be written to convert IBM values to other platforms.

```

program check
real*4 mean,maxval,minval,diff,maxdiff,total,
>      maxmax,minmin,meanmax,diffmax,dummy,xmean,maxvar
double precision passord(4000,2),ra(4000)
character*80 filename
character*4 choice,test
dimension idata(1500,2),data(1500,27)
integer*4 count,var,countall,type,row,col,zero,pass,eight,
>      recnum,passnum(4000),passmj(4000,2)
common /hsort/ ra
c
c----- program description
c
c   check locates all passes with a minimum below a user defined
c   value, a maximum above a user defined value, a variance above
c   a user defined maximum, a mean value beyond a user defined value
c   and a difference between adjacent observations greater than a
c   user defined value. if a pass is selected, then the pass number
c   and the above values are written to the screen. this program
c   can be used on direct access 21-27r files or on files with a
c   header and one variable per pass. this program is used to find
c   passes which are influenced by external fields as noted by
c   their variance properties.
c
c   program date: 22 apr 91
c
c   updates: 6 jun 92; added sort subroutine
c   NOTE: check now removes the checked passes (ie. the high
c         variance passes) from the ordered pass number file
c         written by reorder.
c   NOTE: now check also orders the output file according to
c         the average elevation of the pass.
c   NOTE: these new options are not available for 21-27r input.
c   20 jul 92; added output file on unit 21
c   NOTE: this update simplifies the useage of check
c
c
c   write (*,*) '0 IF INPUT FILE IS 2I-27R'
c   write (*,*) '1 IF INPUT FILE IS HEADER AND VARIABLE'
c   read (*,*) type
c   if (type) 50,50,200
c
c   50  write (*,*) 'INPUT 2I-27R FILE:'
c   read (*,9990) filename
c   9990 format (a80)
c   open (10, file=filename, status='old', form='unformatted',
c   >      access='direct', recl=116)
c----- recl=29 for a dec3100
c   write (*,*) 'WHICH VARIABLE DO YOU WANT FROM THE 27'
c   write (*,*) 'lat lon rad mlt invlat diplat bs bv x y z'
c   write (*,*) 'bva xa ya za totfld xfld yfld zfld inc dec'
c   write (*,*) 'totmag totavgmag resid resavgmag ringcur sec'
c   read (*,*) var
c   write (*,*) 'MAXIMUM ABSOLUTE VALUE FOR MEAN WITHOUT TELLING YOU'
c   write (*,*) 'MAXIMUM VALUE FOR DIFFERENCE'
c   write (*,*) 'MAXIMUM VALUE FOR VARIABLE'
c   write (*,*) 'MINIMUM VALUE FOR VARIABLE'
c   write (*,*) 'MAXIMUM VARIANCE FOR VARIABLE'
c   read (*,*) meanmax,diffmax,maxmax,minmin,maxvar
c
c   write (*,*) 'PASSNO CNT      MAX          MEAN          MIN',
c   >      DIFF      MAXVAR'
c
c   21  jstop=0
c       recnum=1
c       countall=0
c       count=0
c       read (10,rec=recnum) (idata(1,i),i=1,2), (data(1,j),j=1,27)
c   n=2
c   22  recnum=recnum+1
c       read (10,rec=recnum,err=24) (idata(n,1),i=1,2), (data(n,j),j=1,27)
c       if (idata(n,1) .ne. idata(n-1,1)) go to 25
c   n=n+1
c   go to 23
c   24  continue
c   jstop=1
c   25  continue
c
c   countall=countall+1
c   total=0.0
c   xsumsqr=0.0
c   maxval=-10e10
c   minval=10e10
c   maxdiff=10e-10
c   dummy=data(n,var)
c   data(n,var)=data(n-1,var)
c   do 100 i=1,n-1
c       total=total+data(i,var)
c       xsumsqr=xsumsqr+(data(i,var)**2)
c       maxval=max(maxval,data(i,var))

```

```

        minval=min(minval,data(i,var))
        diff=data(i,var)-data(i+1,var)
        maxdiff=max(maxdiff,abs(diff))
100  continue
        mean=total/(n-1)
        xvar=(xsumsqr-((total)**2)/real(n-1))/real(n-2)
        absmean=abs(mean)
        if (absmean.gt.meanmax .or. maxval.gt.maxmax .or.
        > minval.lt.minmin .or. maxdiff.gt.diffmax .or.
        > xvar.gt.maxvar) then
          write (*,9992) idata(n-1,1),n-1,maxval,mean,minval,
                         maxdiff,xvar
        9992  format (2i5,5(1x,f12.6))
          count=count+1
        endif
        data(n,var)=dummy
      c
      27  continue
      do 28 i=1,2
          idata(1,i)=idata(n,i)
      28  continue
      do 29 j=1,27
          data(1,j)=data(n,j)
      29  continue
      if (jstop.eq. 1) go to 999
      go to 22
    c
200  continue
      countall=0
      count=0
      write (*,*) 'INPUT HEADER AND ONE VARIABLE FILE:'
      read (*,9990) filename
      open (10, file=filename, status='old', form='unformatted')
      write (*,*) '1 to work with magnetic variable or latitude'
      write (*,*) '2 to work with longitude'
      write (*,*) '3 to work with radius'
      read (*,*) var
      write (*,*) 'MAXIMUM ABSOLUTE VALUE FOR MEAN WITHOUT TELLING YOU'
      write (*,*) 'MAXIMUM VALUE FOR DIFFERENCE'
      write (*,*) 'MAXIMUM VALUE FOR VARIABLE'
      write (*,*) 'MINIMUM VALUE FOR VARIABLE'
      write (*,*) 'MAXIMUM VALUE FOR VARIANCE'
      read (*,*) meanmax,diffmax,maxmax,minmin,maxvar
      write (*,*) 'REMOVE THESE PASSES FROM THE ORDERED PASS FILE'
      write (*,*) 'yes OR no (choose yes after running several times'
      write (*,*) '           to determine the variance cutoff)'
      read (*,9991) choice
      9991 format (a4)
      if (choice.eq.'yes' .or. choice.eq.'YES') then
        write (*,*) 'INPUT FILE OF ORDERED PASS NUMBERS'
        read (*,9990) filename
        open (11, file=filename,form='formatted',status='old')
        write (*,*) 'OUTPUT FILE = PASS NUMBERS - CHECKED NUMBERS'
        read (*,9990) filename
        open (20, file=filename,form='formatted')
        icnt=0
        do i=1,10000
          read (11,9991) test
          icnt=icnt+1
          if (test.eq. ' new') then
            read (11,9991) test
            go to 205
          end if
        end do
      205  icnt=icnt-2
        write (*,*) 'read ',icnt,' passes from pass file'
        write (*,*) 'OUTPUT FILE OF CHECKED PASSES'
        read (*,9990) filename
        open (21, file=filename,form='formatted')
      c
        do i=1,icnt
          read (11,*) (passmj(i,j),j=1,2), (passord(i,j),j=1,2)
        end do
      endif
      c
      write (*,*) 'PASSNO CNT      MAX          MEAN          MIN',
      >           DIFF      MAXVAR'
      c
210  read (10,end=500) row,col,zero,xmean,pass,eight
      do 220 i=1,row
          read (10) (data(i,j),j=1,col)
      220 continue
      countall=countall+1
      total=0.0
      xsumsqr=0.0
      maxval=-10e10
      minval=10e10
      maxdiff=10e-10
      data(row+1,var)=data(row,var)

```

```

do 240 i=1, row
      total=total+data(i, var)
      xsumsqr=xsumsqr+(data(i, var)**2)
      maxval=max(maxval, data(i, var))
      minval=min(minval, data(i, var))
      diff=data(i, var)-data(i+1, var)
      maxdiff=max(maxdiff, abs(diff))
240  continue
      mean=total/row
      xvar=(xsumsqr-((total)**2)/real(row))/real(row-1)
      absmean=abs(mean)
      if (absmean.gt.meanmax .or. maxval.gt.maxmax .or.
      >      minval.lt.minmin .or. maxdiff.gt.diffmax .or.
      >      xvar.gt.maxvar) then
c
      write (*,9992) pass, row, maxval, mean, minval, maxdiff, xvar
      if (choice.eq.'yes' .or. choice.eq.'YES')
      >      write (21,9992) pass, row, maxval, mean, minval, maxdiff, xvar
c
      count=count+1
      passnum(count)=pass
      endif
      go to 210
c
500  continue
      if (choice.eq.'yes' .or. choice.eq.'YES') then
      jcnt=0
      do i=1, lcnt
          do j=1, count
              if (passmjd(i,1) .eq. passnum(j)) go to 510
          enddo
          jcnt=jcnt+1
          ra(jcnt)=passord(i,2)
510  continue
      enddo
c
      call sort (jcnt)
c
      do i=1, jcnt
          do j=1, lcnt
              if ( ra(i) .eq. passord(j,2) ) then
                  write (20,*) (passmjd(j, jj), jj=1,2), passord(j,1),
                  >                           real(passord(j,2))
                  go to 520
              endif
          enddo
520  continue
      enddo
      endif
999  continue
      close (10)
      close (11)
      close (20)
      write (*,*) 'total passes counted = ', countall
      write (*,*) 'total passes checked = ', count
      write (*,*) 'total passes written to file = ', jcnt
      stop
      end
c
c
      SUBROUTINE SORT(N)
      double precision ra,rra
      common /hsort/ ra(4000)
c-----this subroutine is written by the authors
c                               of: Numerical Recipes (fortran);
c                               The Art of Scientific Computing
c                               Cambridge University Press
c                               1989, p. 230
c                               the routine is referred to as "heapsort"
c                               Copyright (C) :986, 1992 Numerical Recipes Software
c
      L=N/2+1
      IR=N
100  CONTINUE
      IF(L.GT.1)THEN
          L=L-1
          RRA=RA(L)
      ELSE
          RRA=RA(IR)
          RA(IR)=RA(1)
          IR=IR-1
          IF(IR.EQ.1)THEN
              RA(1)=RRA
              RETURN
          ENDIF
      ENDIF
      I=L
      J=L+L
200  IF(J.LE.IR)THEN
          IF(J.LT.IR)THEN

```

```
    IF (RA(J) .LT. RA(J+1)) J=J+1
  ENDIF
  IF (RRA .LT. RA(J)) THEN
    RA(I)=RA(J)
    I=J
    J=J+J
  ELSE
    J=IR+1
  ENDIF
  GO TO 200
ENDIF
RA(I)=RRA
GO TO 100
END
```



```

program statmat
character*70 filename(5), statfile
character*5 done
integer*4 col(5), row(5), count
real*4 nobss, data(500,500,5), colat(5), long(5), space(5),
      >      xmean, ymean
      dimension xdata(250000), ydata(250000)

c----- program description
c statmat defines the basic statistics of the input grids.  see
c the write statements for the specific values calculated.  also,
c the code loops through all input grids and calculates the
c correlation coefficients between all combinations of input
c data.
c
c      write (*,*) 'OUTPUT STATISTICS FILE'
c      read (*,9990) statfile
c      open (25, file=statfile, form='formatted')
c-----read all data into array (row,col,layer or map number)
      i=1
10   write (*,*) 'INPUT MATRIX WITH TPLOT HEADER'
      read (*,9990) filename(1)
9990 format (a70)
      open (10, file=filename(1), status='old', form='formatted')
c
      read (10,*) col(1)
      read (10,*) row(1)
      read (10,*) colat(1)
      read (10,*) long(1)
      read (10,*) space(1)
      read (10,*) ((data(j,k,1),k=1,col(1)),j=1,row(1))
      close (10)
      write (*,*) 'ARE YOU THROUGH YET??'
      read (*,9991) done
9991 format (a5)
      if (done .eq. 'y' .or. done .eq. 'yes') go to 50
      i=i+1
      go to 10
c-----maximum number of input data sets -count
c      loops from line 80 to 400 increment through all
c      maps comparing all possible logical
c      combinations of map to map
50   count=1
      write (*,*) 'total number of input data sets =',count
      do 60 i=1,count-1
         if (col(i) .ne. col(i+1) .or. row(i) .ne. row(i+1)) then
            write (*,*) filename(i), col(i), row(i)
            write (*,*) filename(i), col(i), row(i)
            write (*,*) 'rows or columns do not match'
            stop 0001
         endif
60   continue
c-----from 200 to write statement of variables is
c      the statistical calculations using two
c      references:
c         1) Davis, Statistics and Data Analysis in
c            Geology, 2nd ed., 1986 pp. 41
c         2) Young, Statistical Treatment of Experimental
c            Data, 1962, McGraw Hill, 115-132
c
80   continue
      do 400 icnt=1,count
         do 400 jcmt=icnt,count
c
            do 100 j=1,row(icnt)
               do 100 k=1,col(icnt)
                  ij=(col(icnt)*(j-1))+k
                  xdata(ij)=data(j,k,icnt)
                  ydata(ij)=data(j,k,jcmt)
100   continue
c-----loops that sum x, x**2, y, y**2 and xy
      nobss=row(icnt)*col(icnt)
      if (nobss .ne. 1) stop 0002
      nobss=float(nobss)
      xsum=0.0
      xsumsqr=0.0
      ysum=0.0
      ysumsqr=0.0
      sumxy=0.0
      xmax=xdata(1)
      xmin=xmax
      ymax=ydata(1)
      ymin=ymin
      do 240 j=1,nobss
         xsum=xsum+xdata(j)
         xsumsqr=xsumsqr+(xdata(j))**2
         ysum=ysum+ydata(j)

```

```

        ysumsqr=ysumsqr+(ydata(j4))**2
        sumxy=sumxy+(xdata(j4)*ydata(j4))
        xmax=max(xmax,xdata(j4))
        xmin=min(xmin,xdata(j4))
        ymax=max(ymax,ydata(j4))
        ymin=min(ymin,ydata(j4))
240  continue
c-----find corrected sum of products, covariance
c-----and corrected sum of squares (x) (y)
c
        xmean=xsum/nobss
        ymean=ysum/nobss
        sumprod=sumxy-((xsum*ysum)/nobss)
        covarxy=sumprod/(nobss-1.0)
        xcsumsqr=xcsumsqr-((xsum**2)/nobss)
        ycsumsqr=ycsumsqr-((ysum**2)/nobss)
c-----find variance, standard deviation for x and y
c
        xvar=xcsumsqr/(nobss-1.0)
        yvar=ycsumsqr/(nobss-1.0)
        xstdev=sqrt(xvar)
        ystdev=sqrt(yvar)
c-----find correlation coefficient by Davis method
        corrDxy=covarxy/(xstdev*ystdev)
c-----find slopes, intercepts and correlation
c-----coefficient by Young method
        xslope=((nobss*xsumy)-(xsum*ysum))/((nobss*xsumsqr)-xsum**2)
        yslope=((nobss*xsumy)-(xsum*ysum))/((nobss*ysumsqr)-ysum**2)
        xintcpt=((ysum*xsumsqr)-(sumxy*xsum))/((nobss*xsumsqr)-xsum**2)
        yintcpt=((xsum*ysumsqr)-(sumxy*ysum))/((nobss*ysumsqr)-ysum**2)
        corrXxy=sqrt(xslope*yslope)
c-----write out this mess for individual pass and
c-----overlapping lengths of passes
c
        write (25,*) 'X = ',filename(icnt)
        write (25,*) 'Y = ',filename(jcnt)
        write (25,9992) xmean,ymean,xvar,yvar,xstdev,ystdev
9992 format('X MEAN =',f9.3,' Y MEAN =',f9.3,/,
      > 'X VARIANCE=',f9.1,' Y VARIANCE=',f9.1,' X STDEV =',
      > f8.3,' Y STDEV =',f8.3)
        write (25,9993) covarxy,corrDxy
9993 format ('COVARIANCE XY=',f9.1,' Davis CORRELATION COEF =',f8.3)
        write (25,9994) xslope,xintcpt,yslope,yintcpt,corrXxy
9994 format ('X SLOPE =',f8.3,' X INTERCEPT =',f8.3,' Y SLOPE =',
      > f8.3,' Y INTERCEPT =',f8.3,/, 'Young CORRELATION COEF =',
      > f8.3)
        write (25,9995) xmax,xmin,ymax,ymin
        write (*,*) corrDxy
9995 format('X-MAX =',f9.3,' X-MIN =',f9.3,' Y-MAX =',f9.3,
      > ' Y-MIN =',f9.3,/)
c
c-----increment to next set of passes
400  continue
c
999  continue
        close (10)
        close (25)
        stop
        end

```

D-9

D-9 INTERNAL VIEWS

```

        program part2
c
c---- convert magsat text from ebcdic to ascii, reorder integer bytes,
c---- and translate ibm real to dec real
c
c   editorial note: this code was supplied quite generously by Dr. Gary P.
c                   Murdock
c
c     implicit none
c
c---- parameter storage:
c     integer reclen
c     parameter (reclen=3024)
c
c---- common storage:
c     character*1 ascconv(256)
c     common /e2acom/ ascconv
c     integer*4 recnum,position
c     common /xxyyzz/recnum,position
c
c---- equivalence storage:
c     integer*4 inbufi(reclen/4),outbufi(reclen/4)
c     character*1 inbufc(reclen),outbufc(reclen)
c     equivalence (inbufi,inbufc),(outbufi,outbufc)
c
c---- local storage:
c     integer i1,i2
c     character*80 filename
c     character*1 c1
c
c---- data: (0-no translate, 1=real*4, 2-integer*4, 3=ebcdic)
c     integer*2 headtyp(557) /4*2,4*1,2*2,4*1,2*2,6*0,12*1,30*3,3*2,
c     > 490*1/
c     integer*2 datatyp(756) /5*2,691*1,30*2,30*0/
c
c---- functions:
c     integer*4 realconv
c
c---- constants:
c     c1 = char(1)
c
c     write (*,*) 'input file:'
c     read (*,99901) filename
99901 format (a80)
c     open (21,file=filename,status='old',
c     > access='direct',form='formatted',recl=reclen)
c     write (*,*) 'output file:'
c     read (*,99901) filename
c     open (31,file=filename,
c     > access='direct',form='formatted',recl=reclen)
c
c     recnum = 1
100  read (21,92101,rec=recnum,err=200) inbufc
92101 format (50000a)
c     if (inbufc(4).eq.c1) then
c       do position = 1,557
c         goto (104,101,102,103),headtyp(position)+1
101    outbufi(position) = realconv(inbufi(position))
c       goto 104
102    i1 = position*4
c       outbufc(i1-3) = inbufc(i1)
c       outbufc(i1-2) = inbufc(i1-1)
c       outbufc(i1-1) = inbufc(i1-2)
c       outbufc(i1) = inbufc(i1-3)
c       goto 104
103    i1 = position*4
c       do i2 = i1-3,i1
c         outbufc(i2) = ascconv(ichar(inbufc(i2))+1)
c       end do
104    end do
c     else
c       do position = 1,756
c         goto (108,105,106,107),datatyp(position)+1
105    outbufi(position) = realconv(inbufi(position))
c       goto 108
106    i1 = position*4
c       outbufc(i1-3) = inbufc(i1)
c       outbufc(i1-2) = inbufc(i1-1)
c       outbufc(i1-1) = inbufc(i1-2)
c       outbufc(i1) = inbufc(i1-3)
c       goto 108
107    i1 = position*4
c       do i2 = i1-3,i1
c         outbufc(i2) = ascconv(ichar(inbufc(i2))+1)
c       end do
108    end do
c     end if
c     write (31,92101,rec=recnum) outbufc
c     recnum = recnum+1
c     goto 100

```

```

C
200  stop
end

BLOCK DATA EBC2ASC
  INTEGER*4 LOOKUP(64) /
>   50462976, 2139490716, 193891735, 252579084, 319951120,
> -2029484643, -1886250728, 522067228, -2088599168, 454494852,
> -1953855096, 117835148, -1827237488, 76977556, -1684366952,
> 446567700, -1566466016, -1499093853, 777758887, 556476476,
> -1414878938, -1347506772, 610120112, 1580935466, -1280168147,
> -1212762700, 746371512, 1061052197, -1111704646, -1044332610,
> 591028418, 574433088, 1667391939, 1734763876, -976983704,
> -909588538, 1818979018, 1886350957, -859082127, -791687475,
> 1953726161, 2021095029, -741180807, -673786412, -606414376,
> -539042340, -471670304, -404298268, 1128415611, 1195787588,
> -370652856, -303240214, 1280002685, 1347374669, -269594031,
> -202182160, 1414766428, 1482118741, -168535463, -101124106,
> 858927408, 926299444, -67487432, -66052 /
COMMON /E2ACOM/ LOOKUP
END

INTEGER*4 FUNCTION REALCONV (IBM)
C
IMPLICIT NONE
C
C---- DUMMY STORAGE:
INTEGER*4 IBM
C
C---- EQUIVALENCE STORAGE:
INTEGER*4 IIBM
CHARACTER*1 CIBM(4)
EQUIVALENCE (IIBM,CIBM)
INTEGER*4 IDEC
CHARACTER*1 CDEC(4)
EQUIVALENCE (IDEC,CDEC)
C
C---- common storage:
integer*4 recnum,position
common /xxyyzz/recnum,position
C
C---- LOCAL STORAGE:
INTEGER COUNT
LOGICAL SIGNFLAG
CHARACTER*1 CO
C
C---- "CONSTANTS"
CO = CHAR(0)
C
C---- MOVE ARGUMENT TO EQUIVALENCE AREA
IIBM = IBM
C
C---- SWITCH MANTISSA BYTES INTO dec
CDEC(1) = CIBM(4)
CDEC(2) = CIBM(3)
CDEC(3) = CIBM(2)
C
C---- ZERO NON-MANTISSA BYTE
CDEC(4) = CO
C
C---- CHECK FOR 0.0
IF (CDEC(1).EQ.CO .AND. CDEC(2).EQ.CO .AND. CDEC(3).EQ.CO)
> GOTO 120

C---- SHIFT MANTISSA BITS LEFT UNTIL A 1 IS FOUND, DISCARD THE 1,
C---- KEEP COUNT
COUNT = 0
100  IDEC = ISHFT(IDEC,1)
IF (CDEC(4).NE.CO) GOTO 110
COUNT = COUNT+1
GOTO 100
C
C---- EXTRACT AND CLEAR SIGN BIT
110  SIGNFLAG = BTST(IIBM,7)
IIBM = IBCLR(IIBM,7)
C
C---- CALCULATE NEW EXPONENT
CIBM(2) = CO
CIBM(3) = CO
CIBM(4) = CO
IIBM = IIBM*4-COUNT-130
IF (IIBM.GT.255 .OR. IIBM.LT.0) THEN
  write (*,99901) recnum,position
99901  format ('ibm value out of range in',16,',',13)
  cdec(1) = CO
  cdec(2) = CO
  cdec(3) = CO
  cdec(4) = CO
  goto 120
END IF

```

```
C
C---- MERGE DEC SIGN, EXPONENT AND MANTISSA
CDEC(4) = CIBM(1)
IDEC = ISHFT(IDEC,-1)
IF (SIGNFLAG) IDEC = IBSET(IDEC,31)
C
120  REALCONV = IDEC
RETURN
END
```

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<p>The FORTRAN programs supplied in this document provide a complete processing package for statistically extracting residual core, external field and lithospheric components in Magsat observations. To process the individual passes: 1) orbits are separated into dawn and dusk local times and by altitude, 2) passes are selected based on the variance of the magnetic field observations after a least-squares fit of the core field is removed from each pass over the study area, and 3) spatially adjacent passes are processed with a Fourier correlation coefficient filter to separate coherent and non-coherent features between neighboring tracks. In the second stage of map processing: 1) data from the passes are normalized to a common altitude and gridded into dawn and dusk maps with least squares collocation, 2) dawn and dusk maps are correlated with a Fourier correlation efficient filter to separate coherent and non-coherent features; the coherent features are averaged to produce a total field grid, 3) total field grids from all altitudes are continued to a common altitude, correlation filtered for coherent anomaly features, and subsequently averaged to produce the final total field grid for the study region, and 4) the total field map is differentially reduced to the pole.</p>			
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